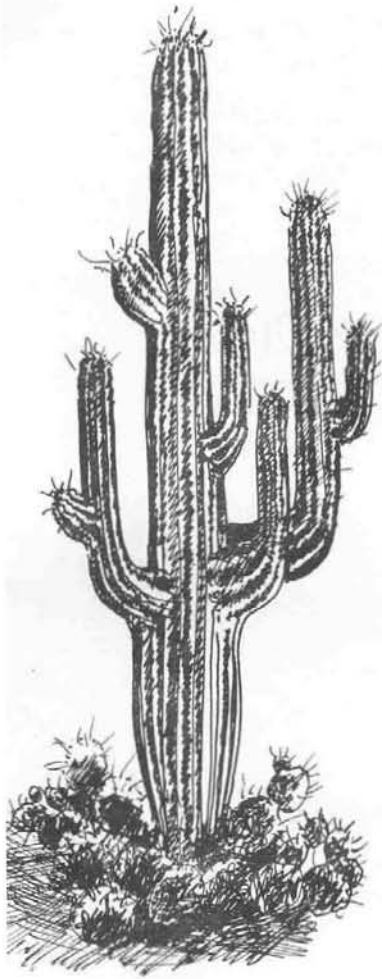




Cooperative National Park

RESOURCES STUDIES UNIT

TECHNICAL REPORT NO. 3

ECOLOGICAL INVESTIGATION OF NATURAL COMMUNITY STATUS

ORGAN PIPE CACTUS NATIONAL MONUMENT

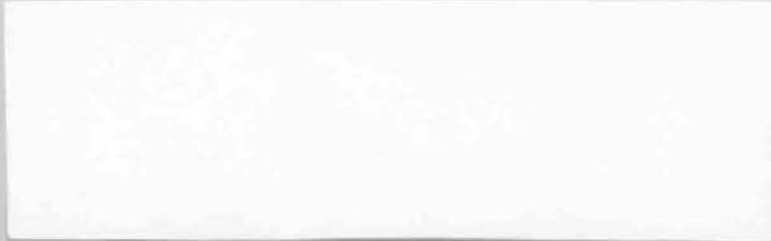
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NATIONAL PARK SERVICE/UNIVERSITY OF ARIZONA

Contract No. CX 8000-4-0033

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Preliminary Ecological Investigation of Natural Community
Status at Organ Pipe Cactus National Monument

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ABSTRACT

Ecological investigations on four major biotic communities at Organ Pipe Cactus National Monument were conducted from September 1974 to June 1976 to document and evaluate the status of natural desert communities that have been subjected to more than 50 years of intensive livestock grazing pressure. Data on plant community structure and composition and rodent populations were obtained from preexisting livestock exclosures, and a series of permanent study plots established along transects in four representative biotic communities. Aerial and ground photography was employed to provide supplemental data on plant community status.

Large-scale color-infrared aerial photographs are a useful tool for documenting and monitoring the status of desert plant communities. Estimates of plant density and ground cover derived from aerial photographs are lower than those provided by ground truth. Accuracy of estimates decreases with increased complexity and stratification of the plant community.

Differences in the complexity of the four biotic communities sampled are characterized by significant differences in plant community structure and composition. Both plant and rodent species diversity increases with plant density and cover. Soil texture directly limits the distribution and abundance of some rodent species.

Intensive livestock grazing directly reduces perennial plant cover and species diversity, and indirectly alters rodent species diversity and abundance. Existing biotic communities have been grossly altered in both structure and species composition under long continued intensive livestock grazing pressure. Grazing-caused erosion in some localities has progressed to a point where reestablishment of original natural biotic communities is impossible.

Progressive deterioration of unique biotic resources is occurring under the pressure of continuing livestock grazing. Such consumptive use is wholly incompatible with the legislated purposes of the monument. Fulfillment of the intended purposes of Organ Pipe Cactus National Monument urgently demands the complete elimination of domestic livestock grazing at the earliest possible date.

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INTRODUCTION

Organ Pipe Cactus National Monument is located in western Pima County in southwestern Arizona immediately adjoining the Mexican state of Sonora,§ and comprises an area of 330,779 acres (517 square miles). It is situated near the geographic center of the Sonoran Desert, and encompasses a unique ecotone between three major subdivisions of that desert.

The monument, established by Presidential proclamation in April 1937, was created primarily to protect the integrity of its diverse and unusual flora and fauna. However, the natural biotic communities of the area have been subjected to more than a half-century of intensive grazing pressure which has exerted an undetermined impact upon the original natural communities. There have been no studies designed to document qualitatively the status of these communities, or to measure the impact of livestock grazing on natural community structure and composition. The lack of such information has seriously impaired National Park Service efforts to control or eliminate livestock grazing, and to develop and implement management programs for the restoration of degraded environments.

The historical record of livestock grazing within the monument is incomplete. Schultz (1966) notes that grazing activity in the area probably pre-dates the establishment of the monument by 50 years or more, and that cattle have grazed the area more-or-less continuously since 1920. He cites numerous reports of excessive numbers of cattle, overgrazing, and damage to vegetation since the monument was established.

In 1938, a permit was issued by the National Park Service to Jose Juan Orosco to graze 100 cattle in the monument. The permit was continued until 1946. Beginning in 1939, Robert L. Gray and sons were authorized to graze 550 cattle yearlong. Since 1943, permits

issued to the Gray family have authorized yearlong grazing of 1050 cattle. At times, however, numbers of cattle grazing in the monument have far exceeded authorized numbers. In 1942, 16,673 cattle were reported. In 1965, the estimated number of cattle was 1375.

The Schultz report (1966) describes seriously overgrazed conditions of vegetation in several portions of the monument and recommends corrective grazing practices. These include a reduction of cattle (more than 6 months of age) to 314 animals, measures to control distribution, annual range utilization checks, and systematic range-use supervision. The recommendations were not implemented

By order of the Secretary of Interior, no grazing permits have been issued since 1968. However, cattle continue to graze on the monument pending court action to determine the legality of cattle grazing.

There are few reports bearing on the question of natural community status and grazing relationships at Organ Pipe Cactus National Monument. Huey (1942) provides an annotated record of the occurrence of vertebrate animal species in the monument in 1939. Mulroy (1971) reported on plant species associated with the organpipe cactus (Cereus thurberi). A forage resources inventory by Schultz (1966) constitutes the only comprehensive report on grazing within the monument.

The complex and controversial interrelationships of cattle grazing, rodents and jackrabbits, fire, and climatic change and their relationship to historic vegetation changes in Arizona and northern Sonora are discussed by Hastings and Turner (1965). Vorhies and Taylor (1933, 1940), Taylor et.al. (1935), Reynolds and Glendening (1949), and Reynolds (1950, 1958) investigated relationships between mammals (kangaroo rats, woodrats, and jackrabbits) and grazing in desert grass land communities; however, they addressed themselves primarily

to the question of the deleterious effect of native mammals on livestock forage plants. Other studies on the effect of grazing on desert vegetation (Hanson and Ball 1928, Shreve 1929, Shreve and Hinckley 1937, Blydenstein et al. 1957) did not examine relationships between grazing and small mammal populations.

This investigation establishes baseline data on plant and rodent populations in the four principal biotic communities under current grazing pressure at Organ Pipe Cactus National Monument. Establishment of permanent study plots and gathering of field data were carried out from September 1974 to June 1976. Simultaneous sampling of plant and rodent populations occurring under differing livestock grazing pressures required by our experimental design provides a basis for evaluating relationships between grazing intensity, and biotic community structure and composition. Quantitative, reproducible techniques employed in this investigation are specifically intended to provide baseline data and methods for use in future studies to determine the nature and extent of changes occurring in these communities. This report completes the preliminary phase of this long-range study.

Acknowledgements

We are indebted to the Superintendent and members of the staff of Organ Pipe Cactus National Monument for their cooperation and assistance in the conduct of this study. We thank Lupe P. Hendrickson for her competent assistance with preparation of the manuscript.

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METHODS AND MATERIALS

Plant Communities

Three major phytogeographic subdivisions of the Sonoran Desert are represented in Organ Pipe Cactus National Monument (Shreve 1951, Lowe 1964). These are the Lower Colorado section, the Arizona Upland section, and the Sonoran Gulf Coast section. The creosotebush-bur-sage (Larrea Ambrosia) community, the paloverde-saguaro (Cercidium Cereus) community, and the Bursera Jatropha community are plant communities typical of each of these major subdivisions. In addition to saltbush (Atriplex sp.) which is not these three communities, restricted to any one of the Sonoran Desert subdivisions forms an important community type in Organ Pipe Cactus National Monument.

The creosotebush-bur-sage community is found on the open and relatively level valley bottoms forming one of the simplest, open vegetation types of the monument (Fig. 1). low elevations, to the west of the monument, creosotebush (Larrea divaricata) and white bur-sage (Ambrosia dumosa) cover large areas, often in relatively pure stands, constituting the dominant members of the Lower Colorado or California Microphyll section.

The Arizona Upland section is best developed on the rockier upper bajadas and lower mountain slopes (Fig. 2). There, the paloverde-saguaro community is dominated by trees and arobrescent cacti as well as by numerous shrub species. This structurally and floristically diverse community occurs widely in Arizona at intermediate elevations north and to the east of the monument, extending to the northeastern limits of the Sonoran Desert near the San Pedro and Gila rivers.

Species typical of the Bursera Jatropha community of the Central Gulf Coast section are incompletely represented in a small area around Senita Basin (Fig. 3). These have ranges

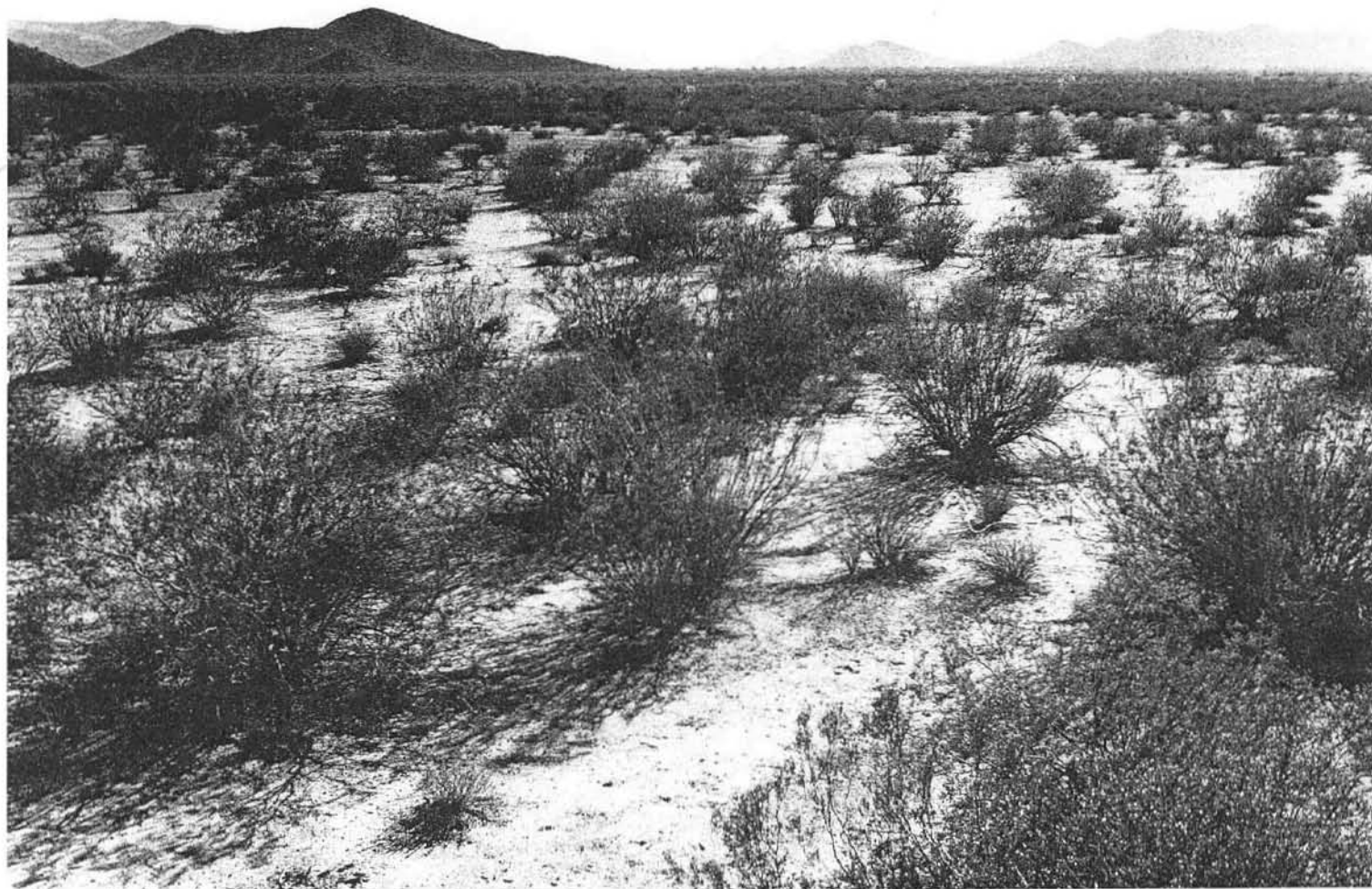


Fig. 1. Creosotebush-bur-sage community on the lower bajada of Growler Valley, plot no. 1SE3. Structurally and floristically this is the simplest of the communities examined. The dominant shrub is creosotebush (Larrea divaricata). Photographed 19 December 1974.



Fig. 2. Paloverde-saguaro community at the mouth of Alamo Canyon, plot 300. This is one of the most diverse communities in the monument. Trees in the foreground are paloverde (Cercidium microphyllum) and desert ironwood (Olneya tesota). Low shrubs are triangle bur-sage (Ambrosia deltoidea). Cacti visible in the photograph are saguaro (Cereus giganteus) and cholla (Opuntia sp.). Photographed 10 April 1975.

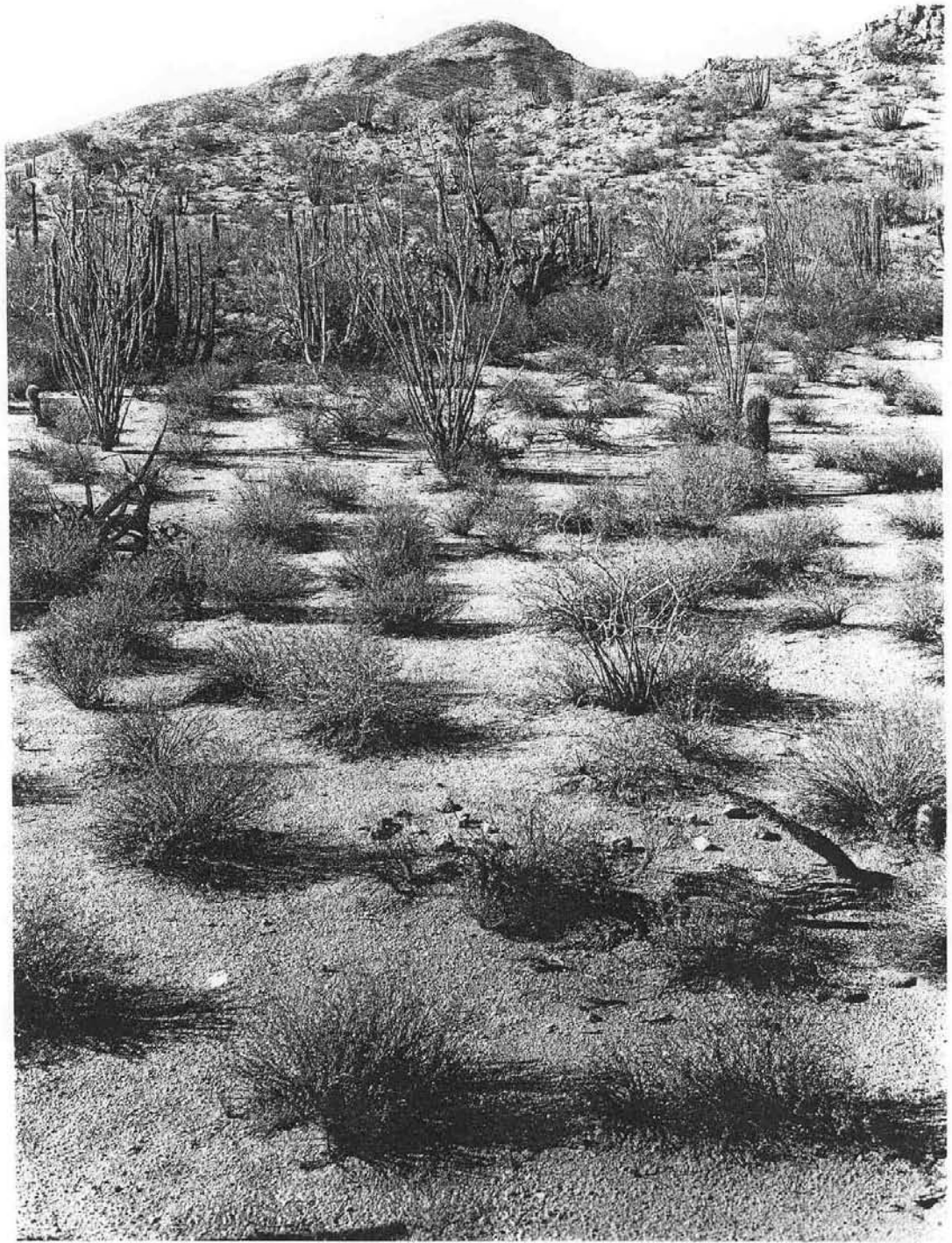


Fig. 3. Bursera-Jatropha community in Senita Basin, plot 400. This community contains numerous subtropical components. In the foreground are triangle bur-sage (Ambrosia deltoidea), and limberbush (Jatropha cardiophylla) at right center. Ocotillo (Fouquieria splendens), saguaro (Cereus giganteus), and organpipe cactus (Cereus Thurberi) can be seen in the background. Elephant tree (Bursera microphylla) occurs on the hills in the background. Photographed 2 May 1976.

extending to the south and encompassing the arid, lowelevation region of coastal Sonora (Hasting et al. 1972, Shreve 1951). Saltbush (Atriplex sp.) which occurs mainly along the south boundary of the monument sometimes forms extensive stands on flat valley bottoms with fine-textured soil (Fig. 4).

Scientific and vernacular names generally follow Kearney and Peebles (1969) for plants, except for cacti which follow the classification used by Benson (1969). Nomenclature for mammals is from Cockrum (1960).

Vegetation Documentation and Analysis

In each of the four major plant communities, transects were established employing a series of permanent 0.1-ha study plots (see Appendix I for locations). Study plots were established along a gradient of decreasing livestock-use intensity radiating outward from sites of heavy use, such as corrals and watering facilities (Fig. 5). Within each community, transects were oriented to minimize variation in environmental parameters such as soil texture, topography to insure that vegetation differences noted could be attributed to biotic rather than abiotic factors.

Some previous analyses of Sonoran Desert vegetation have utilized 1-m² quadrats (McGinnies 1934, Blydenstein et al. 1957). However, on the basis of sampling technique discussion by Oosting (1956) and desert vegetation studies by Whittaker and Niering (1965), larger 0.1-ha plots are considered more suitable for adequate sampling of the typically arborescent vegetation of the Sonoran Desert.

Two fenced exclosures, established in March 1963, were examined and compared with adjacent unprotected control plots (Fig. 5). The larger of the two exclosures, located in a creosotebush community near Armenta Well on the north monument boundary, encloses an area

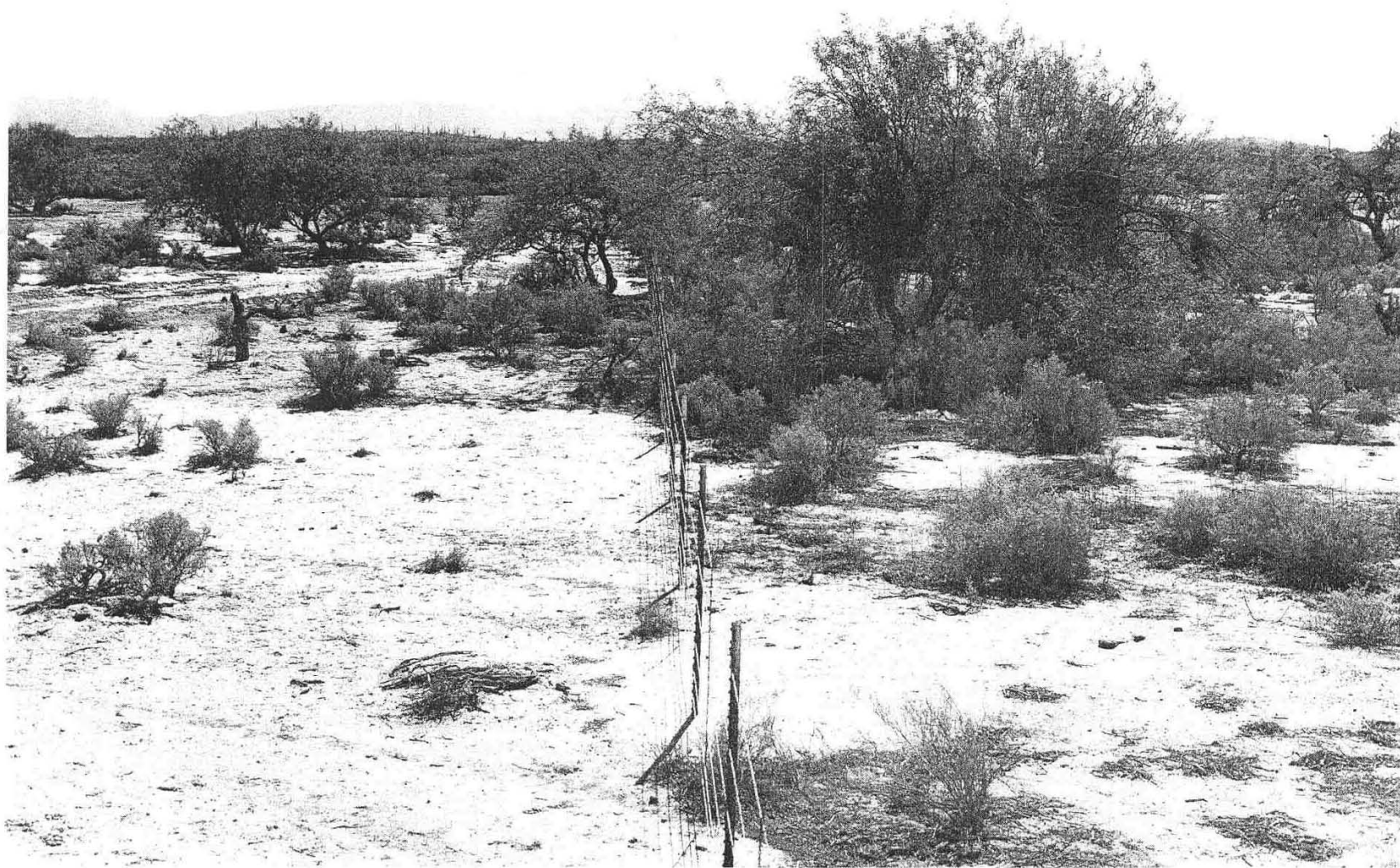


Fig. 4. *Atriplex* community at Dos Lomitas. The trees are mesquite (*Prosopis juliflora*). Note the more robust appearance of the shrubs and the accumulation of dead plant material on the ground within the enclosure on the right. Photographed 1 December 1975.

of approximately 4.0 ha. The second enclosure, located on the south monument boundary near Dos Lomitas in a saltbush community, encloses an area of approximately 1.3 ha. The six-strand barbed-wire enclosures effectively exclude livestock and perhaps deer; however, small mammals are not affected.

Transect no. 1 was established in a cresosotebush-bur-sage community in Growler Valley. From its origin at a livestock watering tank 1/4-mile west of the Cabeza Prieta-Bates Well Road junction, the transect extends southeastward for 2.7 miles. Plots along transect no. 1, (N = 4) were situated on generally level sites with fine-grained soil. Areas of desert pavement, which often possess very depauperate vegetation (Musick 1975), and swales, with stands of mesquite, were avoided.

Transect no. 2 originates in a saltbush community at Aguajita Spring. The transect extends eastward for 2.6 miles, parallel to the monument boundary, and crosses rolling terrain dissected by washes. Along the transect, study plots (N = 4) were located at sites with approximately level terrain and fine-textured soil. A primary consideration in the selection of plot sites was the presence of saltbush as a community dominant.

Transect no. 3 originates near the mouth of Alamo Canyon, an area of high livestock activity due to the proximity of two watering sites. The transect extends southward along the base of the Ajo Mountains for 4.9 miles through the paloverde saguaro community of the upper bajada. Factors considered when selecting study plot sites (N = 5) were soil texture (coarse structure and many cobbles) and slope (gentle but not level). Community dominants at each plot site include paloverde (Cercidium microphyllum) and saguaro (Cereus giganteus).

Livestock watering facilities were not a factor in selecting study plot sites along transect no. 4 in Senita Basin, since none exist in the immediate vicinity. Each plot (N = 3) was located

in approximately level terrain with coarse gravelly soil of granitic origin. The plant community at each plot site included organpipe cactus (Cereus thurberi), limber-bush (Jatropha sp.), and trees such as paloverde and ironwood (Olneya tesota).

The lengths of transects 1, 2, and 3 were based on the maximum distance from water at which livestock can effectively forage (Schultz 1966). The greatest impact from grazing occurs in the immediate vicinity of watering sites and disturbance decreases rapidly with increasing distance from origin. Therefore, the interval (approximately 1/2 mile) between the origin and the second plot in each transect was the shortest. Additional plots in each transect were located at approximately 1-mile intervals. The long axis of each 0.1 ha study plot (20 x 50 m) is oriented north and south. The four corners of each plot are marked with 1/2-inch reinforcing steel stakes with approximately 6 inches exposed above ground. An aluminum tag attached to each corner stake contains the following information: transect number, direction from the transect origin, plot number, and corner designation. At origin plots, zeros are substituted for direction and plot number. Thus, the southeast corner of the origin plot of transect no. 2 is indicated by: 200 SE; the southeast corner of the second plot is indicated by: 2E2 SE, etc..

The southeast corner of each 0.1-ha plot was used as the origin point for sampling. The baseline for sampling each plot extended north along the east side (the long axis) of each plot. For sampling, each plot was outlined with steel surveyor's tapes. Beginning at the origin corner, transect lines were oriented perpendicular to the baseline at 5-m intervals along the baseline providing a total of 11 parallel 20-m transects per plot. Perennial plant cover was measured on each of these lines using the line intercept method of Canfield (1941, also see Mueller-Dombois and Ellenberg 1974), with measurements starting from the baseline. Plant cover data was reduced to percent of total transect length

intercepted by plant canopies. Three additional lines established parallel to the baseline at 5-m intervals were used to subdivide the plots into forty 5 x 5-m subplots. Within each of these subplots all perennial plants were identified and counted, yielding data on total density and species presence (Appendix II, III). Height measurements were made of selected species beginning at a random point within the plot and measuring the nearest individuals of each species until an adequate sample size (25 to 35 individuals) was obtained. In some cases it was necessary to measure individuals off-plot to obtain an adequate sample size. Specimens of all unknown or unusual species were collected. These were returned to the University of Arizona where herbarium facilities were used to aid in identification.

The Student t-test (Simpson et al. 1960) was used for statistical comparison of data from plots along each transect. Significance was determined at the 0.05 probability level. Each line transect within each plot was treated as an individual sample ($N = 11$ per plot). For density comparisons, four adjacent 5 x 5-m subplots were considered as individual 100 m² samples ($N = 10$ per plot). Species diversity of perennial plants in each plot was estimated by the Shannon-Wiener formula (Pielou 1966).

At the Armenta Well enclosure site, a 4-ha control plot was established parallel to, and 30 m east of the enclosure (Fig. 6). The dimensions (128 x 315 m) and orientation of the control plot are the same as those of the enclosure. Each corner of the control plot is marked by an aluminum tag fastened to a 1/2-inch reinforcing-steel stake and marked with the symbol "AWC" and identifying corner location (i.e., NE, SW, etc.).

The origin point for the enclosure data is the southeast corner. The southwest corner is the origin point of the control plot. The baseline for both plots extends north from the plot origin point. Line transects ($N = 9$) for estimating cover were oriented perpendicular to the baseline at

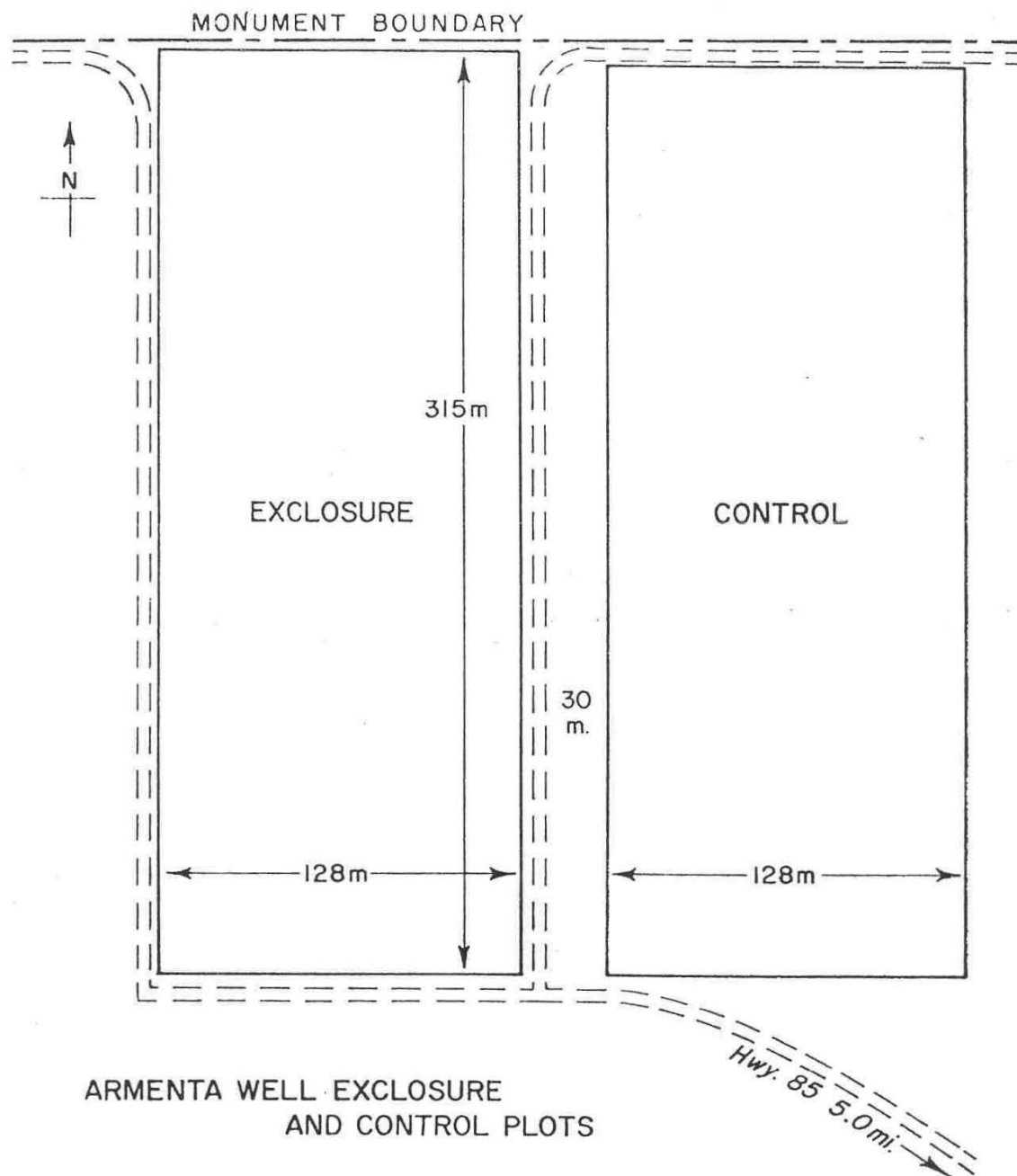


Fig 6. Diagram of the exclosure and control plots at Armenta Well

31-m intervals. Three lines placed parallel to the plot baseline at 32-m intervals across the plot were used to divide the enclosure into forty 31 x 32-m subplots. All perennial plants within each subplot were identified and counted. Creosotebushes, which often grow in clones, were considered to be individuals if their stems were more than 1 m apart or if there was less than 50% crown overlap with adjacent plants.

One half of the control plot was sampled in a manner similar to that used for the enclosure. Beginning at the plot origin, the southern half of the control (2 ha) was sampled as described above, providing a total of twenty 31 x 32-m subplots and five 128-m line transects. Each subplot and each line transect was considered as an individual sample for statistical comparison. Density values were converted to number of plants per 100 m² for comparison with 0.1-ha transect plots.

A 1.3-ha control plot at Dos Lomitas was established 20 m north and 40 m west of the enclosure (Fig. 7). It is oriented parallel to and is the same size as the enclosure (173 x 77 m). The corners of the Dos Lomitas control plot are marked in the same manner as other plots using steel stakes and aluminum tags (plot symbol "DLC"). The southwest corner of each plot is the origin point for plant measurements. The long axis of each plot runs east-west and in both cases the south side of the plot was used for the baseline. Nine 77-m line transects were oriented perpendicular to the baseline of each plot, spaced at 17.3-m intervals. All measurements originated from the plot baselines. Three lines placed parallel to the baselines of the plots at 19.2-m intervals across the plot were used to divide each into forty 17.3 x 19.2-m subplots in which all perennial plants were counted. For statistical comparison, all line transects and subplots were considered as individual measurements. Density data were converted to number per 100 m² for comparison with the 0.1-ha study plots.

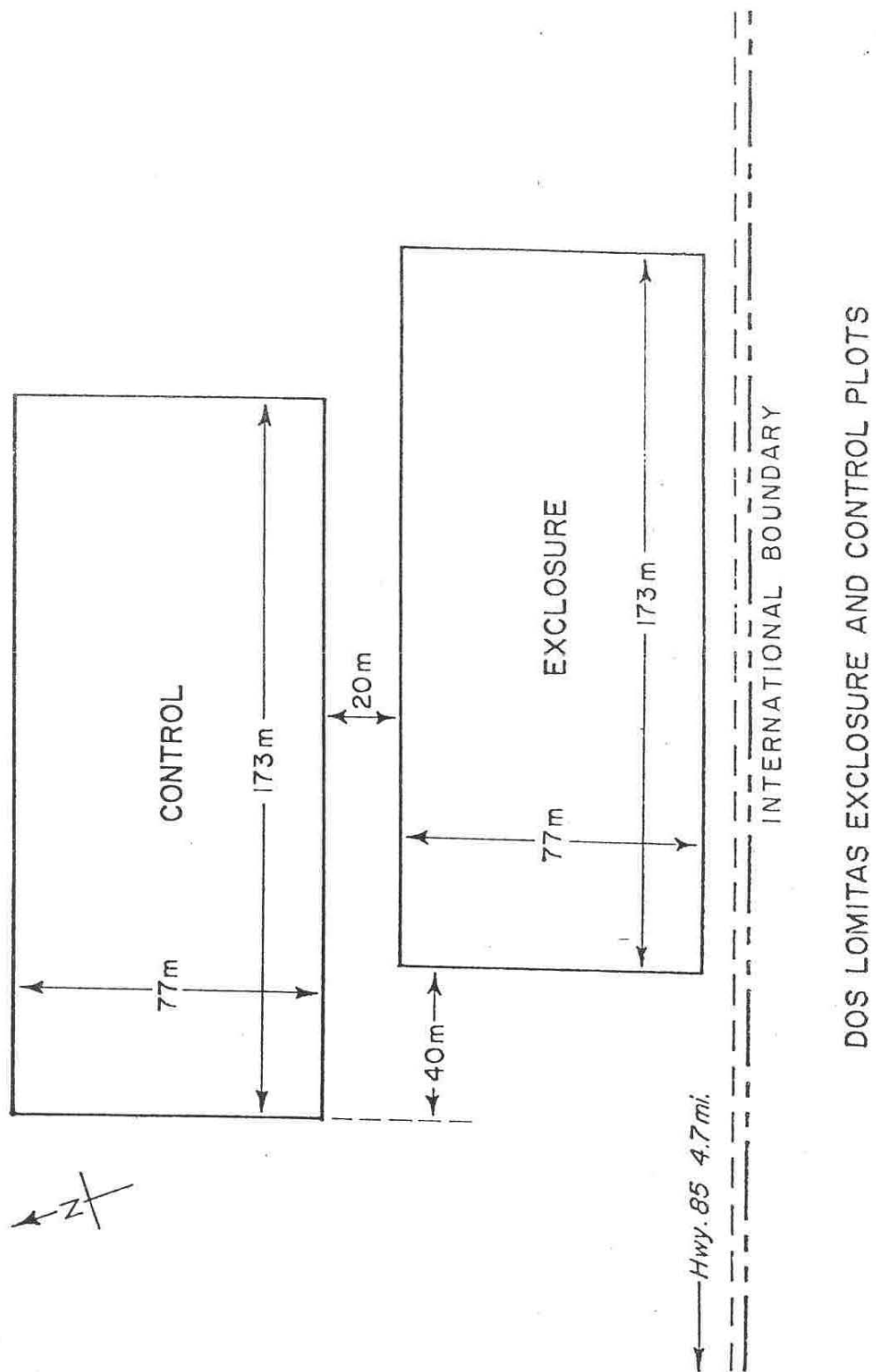


Fig. 7. Diagram of the enclosure and control plots at Dos Lomitas

Collection of data on annual plants could not be completed as provided by the original experimental design. The amount and seasonal distribution of precipitation during the study were not adequate for successful germination and establishment of annual plants in most of the area (see Went 1949).

Storing precipitation gauges fabricated from 1-quart metal containers installed at four study sites were read at approximately 2-month intervals from the start of the study (Appendix IV).

At each 0.1-ha plot and each exclosure site, a soil sample pit was dug to a depth of 1 m. Soil samples were taken at 10-cm intervals to the bottom of each pit, sealed in soil tins, and returned to the University of Arizona where water content was determined by drying (Appendix V). The rock component of each sample was removed in the field and its contribution to soil structure estimated as percent by volume. Mechanical analyses and total soluble salts analyses were performed by the University of Arizona College of Agriculture Soil, Water Testing Laboratory (Appendix VI). Total soluble salts were recorded as parts per million of a saturated soil extract.

Low-altitude, large-scale aerial photographs of each study plot and exclosure-control pair were obtained. Photographs were taken on 9-in color-infrared film. Scales ranged from 1:500 for the 0.1-ha plots to 1:2130 for the Armenta Well exclosure. Estimates of perennial plant density and cover were made from the aerial photographs. Ground-truth data were used for identification of many of the most distinctive plant species in the photographs. Aerial photographs were taken in March, June, August, and November to assist identification of individual species by revealing specific seasonal differences in phenology. Total counts of all plants visible in the photographs were used for density estimates. Cover was estimated by a

variation of the grid method described by Avery (1968) using a 20-squares-to-the-inch transparent overlay,

Ground level photographic documentation of the vegetation involved photography at the study plots and at permanent photo points throughout the monument. Wherever possible, permanent photo points were located at U.S. Coast and Geodetic Survey benchmarks, which are located at 1-mile intervals along many of the monument roads. At each photo point, photographs were taken from atop a car (approximately 10 feet above ground level) in four directions (see Fig. 5). Photographs were also taken from the top of windmills at several wells in the monument. Wherever possible, photographs were taken overlooking each study plot from atop a car on the adjacent road as well as from the side of the plot away from the road.

Mammal Censusing

Live trapping was used to census mammal populations in all plots (Appendix VII). Rodent population estimates based on the recapture of marked animals were calculated using the Lincoln Index method described by Andrewartha (1967) and Eisenberg (1972). The problems inherent in population estimates derived by this technique have been thoroughly reviewed (Jolly 1963, Eisenberg 1972). However, it is the most practical technique available for the present study.

All study sites were trapped during two or more different months to assure that all species present were represented in the census (Bradley and Mauer 1973). Live trapping data were gathered for a total of 3555 trap nights, each study plot receiving at least 100 trap nights. The interval between mark and recapture trapping periods varied from 4 days to 4 weeks. However, comparison of density estimates from Dos Lomitas derived from trapping periods with different

elapsed times indicates that the variation in elapsed time in the present study does not result in great variation in population estimates.

At each 0.1-ha study plot, 52 traps spaced at 10-m intervals were arranged in a 30 x 130-m rectangular grid of four rows of 13 traps each oriented parallel to the long axis of the plot. Trapping grids were laid out starting at the plot origin corner and extended beyond the plot boundaries on two sides.

Both the exclosure and control plots at Armenta Well were sampled using 100 traps spaced at 10-m intervals on a 90 x 90-m square grid (10 x 10 traps). Both trap grids were contained wholly within the plot boundaries. The trap grids were laid out starting from the plot origin corners.

At each of the Dos Lomitas plots, 100 traps were spaced at 8-m intervals on a 72 x 72-m square grid (10 x 10 traps). The exclosure plot trap grid was laid out north and east from the origin corner. The control plot grid was positioned in the approximate center of the plot to align it with the exclosure plot grid. Both trap grids were contained wholly within the plot boundaries.

Larger mammals, such as ground squirrels (Citellus sp.) and kit foxes (Vulpes macrotis), were present at many of the study plot sites. However, with the exception of brush rabbits (Sylvilagus auduboni) at Dos Lomitas, population estimates of these larger animals were not made. At Dos Lomitas, visual daytime censusing of brush rabbits was made possible by the small area of suitable habitat.

RESULTS AND DISCUSSION

Transect No. 1, Growler Valley

Vegetation.--In this transect the total number of species per plot decreased slightly with increased distance from the origin. However, the species diversity, as estimated by the Shannon-Wiener Index, showed no consistent trend (see [Table 1](#)). The same species occurred in approximately the same order of abundance within each study plot along the transect (Figs. 1, [8-10](#)). The four most important species in this community are creosotebush (Larrea divaricata), triangle bur-sage (Ambrosia deltoidea), tobosa grass (Hilaria mutica), and white ratany (Krameria grayi). Only one of these species, white ratany, is utilized to a large extent by livestock as a forage plant, the others being of insignificant forage value (Schultz 1966). Although the presence of other less abundant perennial species varied from plot to plot, their presence or absence did not significantly alter the composition of the community (see [Tables 2-5](#)).

Creosotebush is the dominant species on all four plots, its coverage far surpassing that of all other species combined. It is the most abundant species on plots 1SE1 and 1SE2. On the other two plots, 100 and 1SE3, it is surpassed in density by triangle bur-sage, white bur-sage, and tobosa grass. Creosotebush showed no evidence of grazing damage and did not change importantly in density or coverage along the transect.

Triangle bur-sage is found on all plots in moderate densities and nowhere does it show grazing damage. White bur-sage also occurs on all plots, and shows evidence of hedging due to grazing. Large variations in density of white bur-sage occur from plot to plot, but the variations show no consistent relationship to distance from the origin (Tables 2-5).

Table 1. Number of perennial plant species per plot and the perennial plant species diversity estimated by the Shannon-Wiener index (H') along Transect No. 1 in the Growler Valley

Plot number	Number of species present	H'
100	7	0.474
1SE1	6	0.661
1SE2	5	0.377
1SE3	5	0.539



Fig. 8. Plot 100, Growler Valley. Creosotebush (*Larrea divaricata*) and triangle bur-sage (*Ambrosia deltoidea*) are the dominant shrubs. The barren areas are desert pavement. Photographed 19 December 1974.

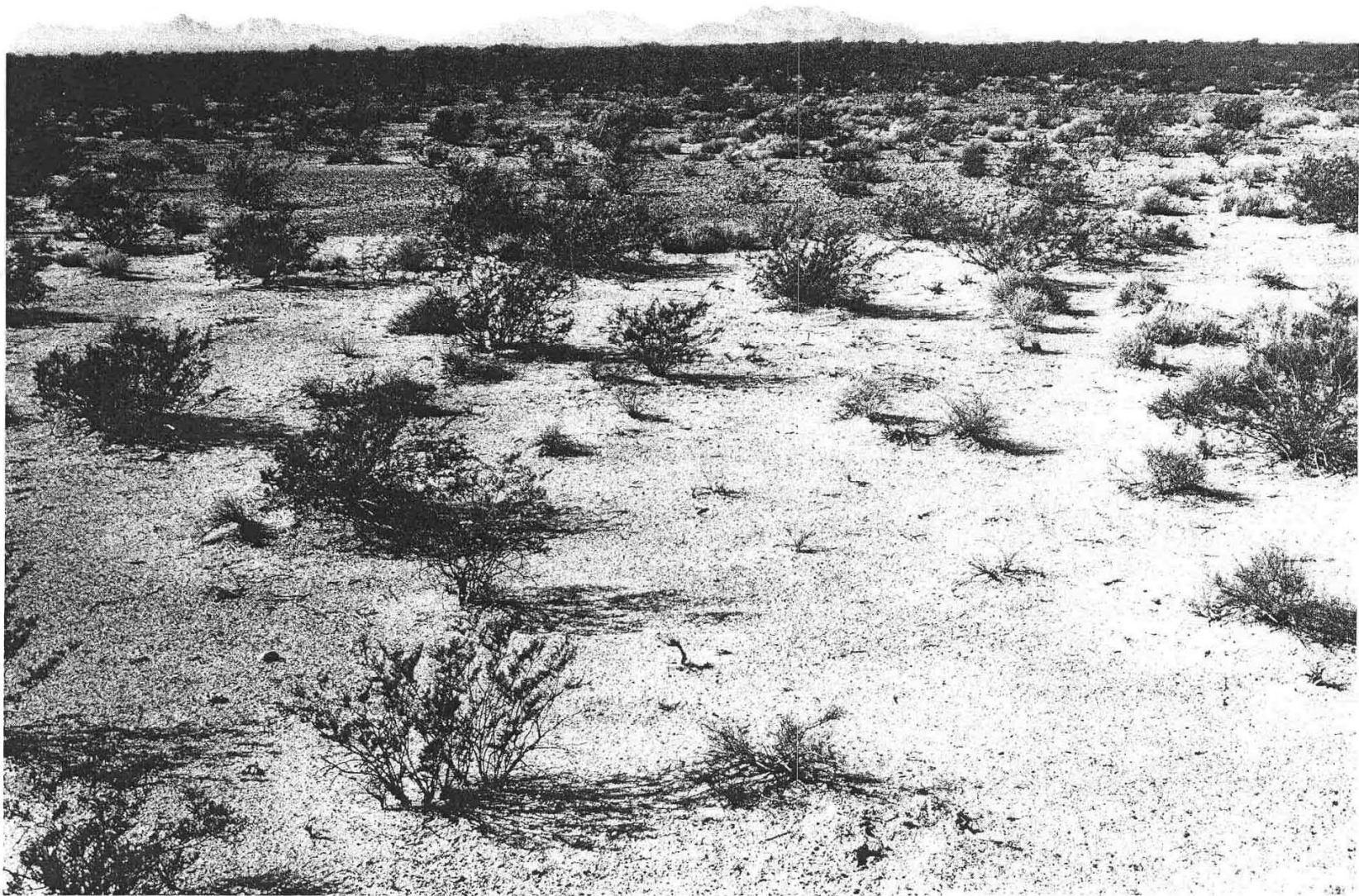


Fig. 9. Plot 1SE1, Growler Valley. Creosotebush (Larrea divaricata) is the dominant species. The low shrub in the center foreground is white ratany (Krameria grayi) which has been hedged by cattle. Photographed 19 December 1974.



Fig. 10. Plot 1SE2, Growler Valley. Creosotebush (*Larrea divaricata*) is the dominant species. A corner stake is visible in the right foreground. Photographed 19 December 1974.

Table 2. Perennial plant density and cover in plot No. 100, Growler Valley.

	Species	Density (no./0.1 ha)	Cover(%)
1.	<u>Larrea divaricata</u>	47	8.32
2.	<u>Ambrosia deltoidea</u>	79	1.80
3.	<u>Krameria grayi</u>	12	0.75
4.	<u>Lycium andersoni</u>	2	
5.	<u>Ferocactus wislizeni</u>	2	
6.	<u>Ambrosia dumosa</u>	1	
7.	<u>Prosopis juliflora</u>	1	
	Total	144	10.87

Table 3. Perennial plant density and cover in plot No. 1SE1, Growler Valley.

	Species	Density (no./0.1 ha)	Cover (%)
1.	<u>Ambrosia dumosa</u>	116	1.84
2.	<u>Larrea divaricata</u>	50	8.43
3.	<u>Hilaria mutica</u>	67	2.54
4.	<u>Krameria grayi</u>	51	2.39
5.	<u>Ambrosia deltoidea</u>	21	
6.	<u>Ferocactus wislizeni</u>	3	
	Total	308	15.20

Table 4. Perennial plant density and cover in plot No. 1SE2, Growler Valley.

Species		Density (no./0.1 ha)	Cover
1.	<u>Larrea divaricata</u>	88	6.82
2.	<u>Ambrosia deltoidea</u>	41	0.73
3.	<u>Ambrosia dumosa</u>	4	
4.	<u>Krameria grayi</u>	3	
5.	<u>Opuntia leptocaulis</u>	1	
Total		137	7.55
		29	

Table 5. Perennial plant density and cover in plot No. 1SE3, Growler Valley.

Species		Density (no./0.1 ha)	Cover (%)
1.	<u>Larrea divaricata</u>	77	17.00
2.	<u>Ambrosia deltoidea</u>	61	1.71
3.	<u>Ambrosia dumosa</u>	29	0.39
4.	<u>Hilaria mutica</u>	12	0.89
5.	<u>Lycium</u> sp.	1	0.11
Total		180	20.10

Of the four community dominants, white ratany was hedged to the greatest extent by grazing. Wherever present it is heavily used and typically grows closely appressed to the ground, unlike its shrubby aspect in undisturbed areas. The sporadic occurrence in the plots of other species such as barrel cactus (Ferocactus wislizeni), wolfberry (*Lyceum* sp.), and Christmas cactus (Opuntia leptocaulis) reflects their sparse and adventitious distribution in the community and they do not exhibit any pattern associated with the distance from the transect origin.

Although all of the species present along transect no. 1 showed variation in density and coverage between plots, the variation beyond plot 1SE1 seems to be unrelated to increased distance from the transect origin (see [Figs. 11, 12](#)). Recent analysis of desert soils (Musick 1975) has shown that large marked increase in desert pavement such as occur in the Growler Valley. It is likely that the variation seen in the plant community along transect no. 1 is attributable to such local variations in microtopography, both of which can affect soil water availability (see Appendix V).

Rodents.--The small mammal communities at each of the study plots were dominated by Merriam's kangaroo rat (Dipodomys merriami), the most common rodent of the creosote-bur-sage community. Two species of pocket mice, the desert pocket mouse (Perognathus penicillatus) and the Arizona pocket mouse (Perognathus amplus), occurred occasionally and a single grasshopper mouse (Onychomys torridus) was captured ([Table 6](#)). The abundance of rodents increased with density and cover of perennial plants. Increased rodent abundance was due primarily to increased densities of pocket mice, which have been shown by Wondolleck (1975) to forage preferentially under plant cover rather than in open microhabitats. Increase in plant cover evidently allows a greater population density of pocket mice by increasing available

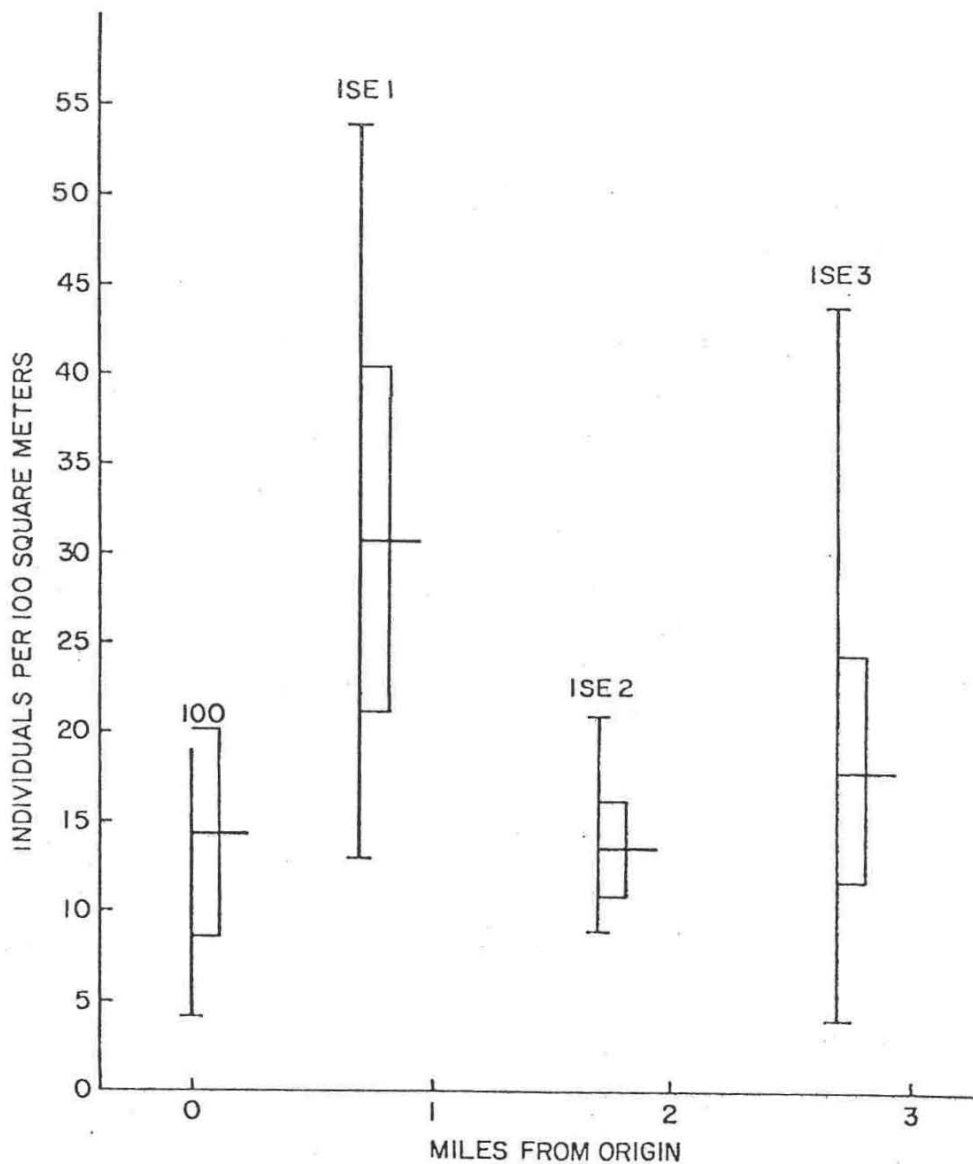


Fig. 11. Mean, range, and 95% confidence interval of perennial plant density in study plots along transect no. 1, Growler Valley. No consistent relationship between plant abundance and distance beyond plot 1SE1 is evident. Statistics in Appendix III.

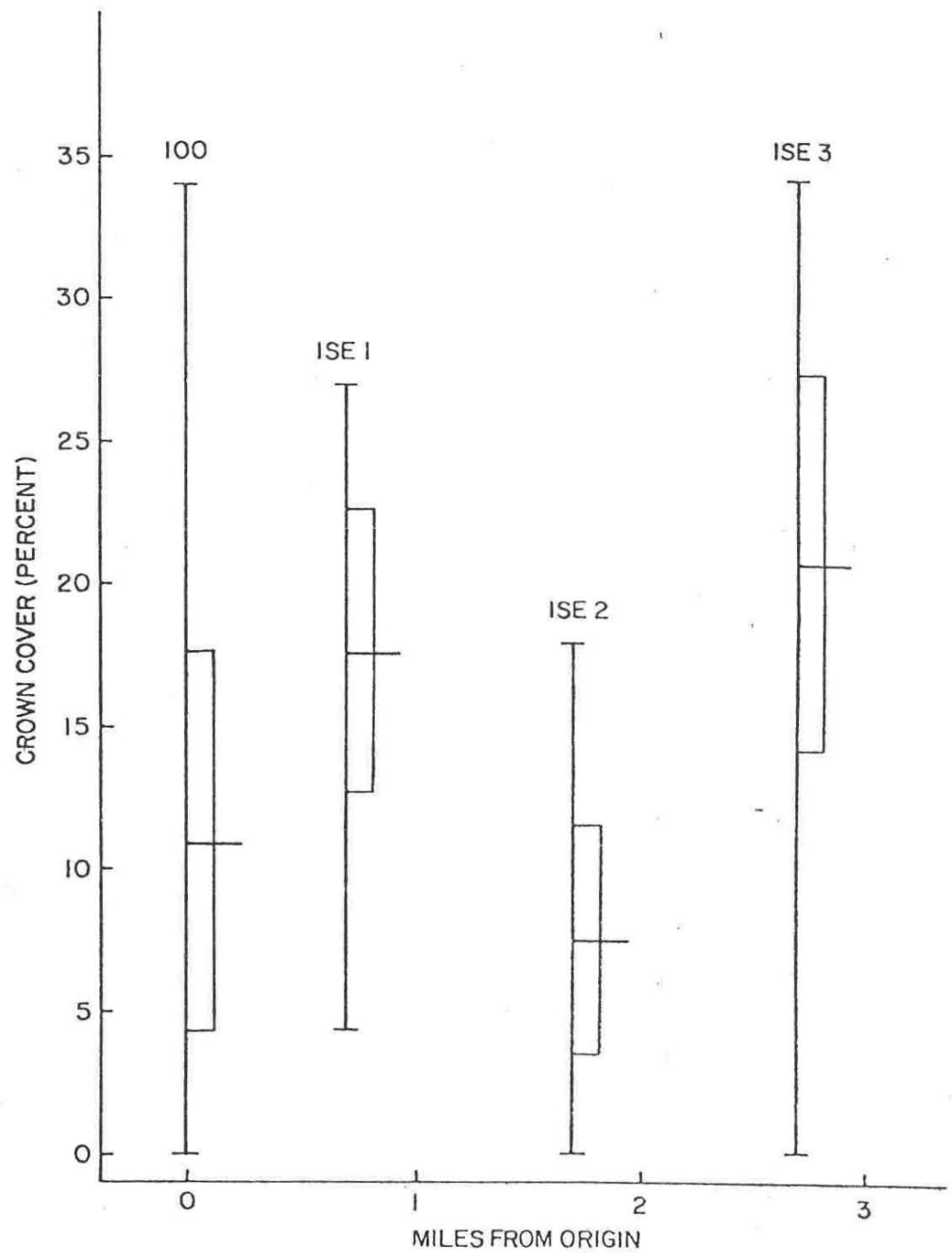


Fig. 12. Mean, range, and 95% confidence interval of perennial plant cover in study plots along transect no. 1, Growler Valley. Statistics in Appendix III.

Table 6. Population data for rodents along Transect No. 1, Growler Valley. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectares. Relative abundance is calculated from density estimate figures. Trapping was carried out during February and April 1976.

Species	Plot 100			Plot 1SE1			Plot 1SE2		
	captures	density	rel. abun.	captures	density	rel. abun.	captures	density	rel. abun.
<u>Dipodomys merriami</u>	18.2	14	0.88	14.6	14	0.64	13.0	11	0.79
<u>Perognathus amplus</u>	1.0	2	0.12	2.3	4	0.18	--	--	--
<u>Perognathus penicillatus</u>	--	--	--	3.1	4	0.18	2.0	3	0.21
<u>Onychomys torridus</u>	--	--	--	--	--	--	--	--	--
Total	19.2	16	1.00	20.0	22	1.00	15.0	14	1.00
Species diversity (H')	0.164			0.394			0.226		
Total trap nights	100			130			100		

Table 6. Continued.

Species	Plot 1SE3		
	captures	density	rel. abun.
<u>Dipodomys merriami</u>	11.3	7	0.88
<u>Perognathus amplus</u>	--	--	--
<u>Perognathus penicillatus</u>	--	--	--
<u>Onychomys torridus</u>	0.8	1	0.12
Total	12.1	8	1.00
Species diversity (H')		0.164	
Total trap nights		133	

foraging microhabitat. There was no correlation between rodent density or diversity and distance from the origin of the transect.

Transect No. 2, Aguajita Spring

Vegetation.--Several major changes occur in the vegetation as one moves eastward from the Aguajita Spring origin of transect no. 2. Both species diversity and total number of species per plot increase with distance from the origin (Table 7). The increase in the species diversity index reflects a two-fold increase in the number of species present and a more equitable distribution of the relative abundance of plant species, i.e., the community is not dominated by a small number of species (Figs. 13-16). Species diversity increases rapidly then levels off to a value slightly more than twice that observed at the transect origin.

In addition to the change in species composition of the community along transect no. 2, a change is seen in the structural character of the vegetation. Density of perennial plants is relatively constant along the transect; no statistically significant differences were found between plots (Fig. 17). Perennial plant coverage, however, increased with distance from Aguajita Spring (Fig. 18). . Plant coverage increases abruptly as one moves away from the origin. Coverage at the origin was significantly lower than in two of the three outlying plots ($P < 0.05$) .

The three dominant species at the transect origin, seepweed (Suaeda torreyana) and two species of saltbush (Atriplex polycarpa, A. linearis) are all members of the Chenopodiaceae and are characteristically indicators of saline soil (Table 8). The almost complete absence of other species at the origin suggests that vegetation differences seen

Table 7. Number of perennial plant species per plot and perennial plant species diversity estimated by the ShannonWiener index (H') along Transect No. 2, Aguajita Spring.

Plot number	Number of species present	H
200	5	0.305
2E1	13	0.621
2E2	10	0.716
2E3	11	0.643



Fig. 13. Plot 200, Aguajita Spring. The shrubs are saltbush (Atriplex polycarpa and A. linearis). Note the severely hedged condition of the shrubs, and mounding at their bases, indicative of erosion. Photographed 20 December 1974.

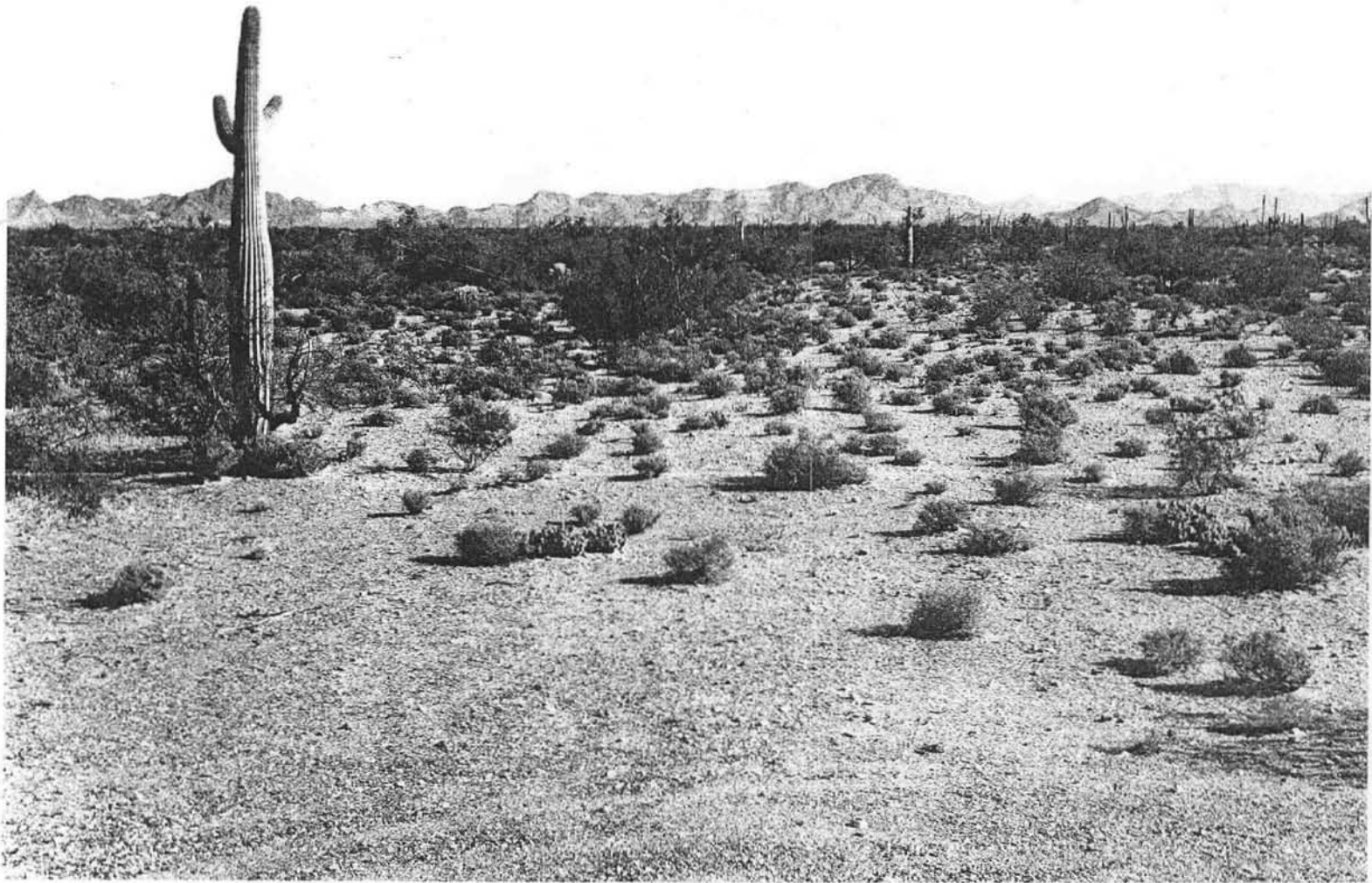


Fig. 14. Plot 2E1, near Aguajita Spring. The foreground species are saltbush (*Atriplex* sp.) and devil cholla (*Opuntia stanlyi*). Trees along the wash in the background are mesquite (*Prosopis juliflora*) and foothill paloverde (*Cercidium microphyllum*). Photographed 20 December 1974.



Fig. 15. Plot 2E2, near AguaJita Spring. Saltbush is co-dominant with creosotebush (Larrea divaricata) and triangle bur-sage (Ambrosia deltoidea). Photographed 20 December 1974.



Fig. 16. Plot 2E3, near Aguajita Spring. U.S. Coast and Geodetic Survey benchmark in right foreground marks one corner of the study plot. Photographed 20 December 1974.

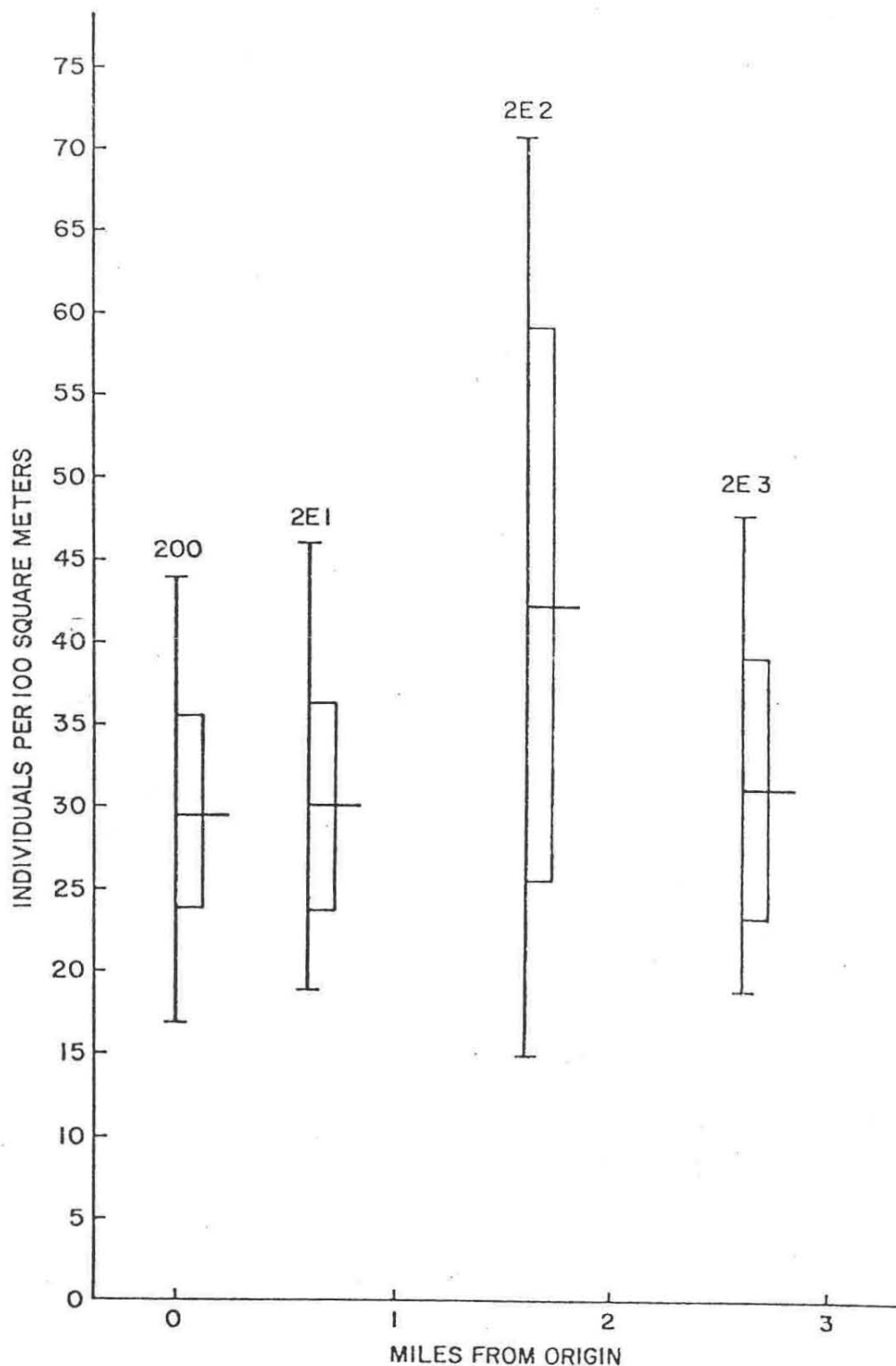


Fig. 17. Mean, range and 95% confidence interval of perennial plant density in study plots along transect no. 2, Aguajita Spring. There is no significant difference in density between the plots. Statistics in Appendix III.

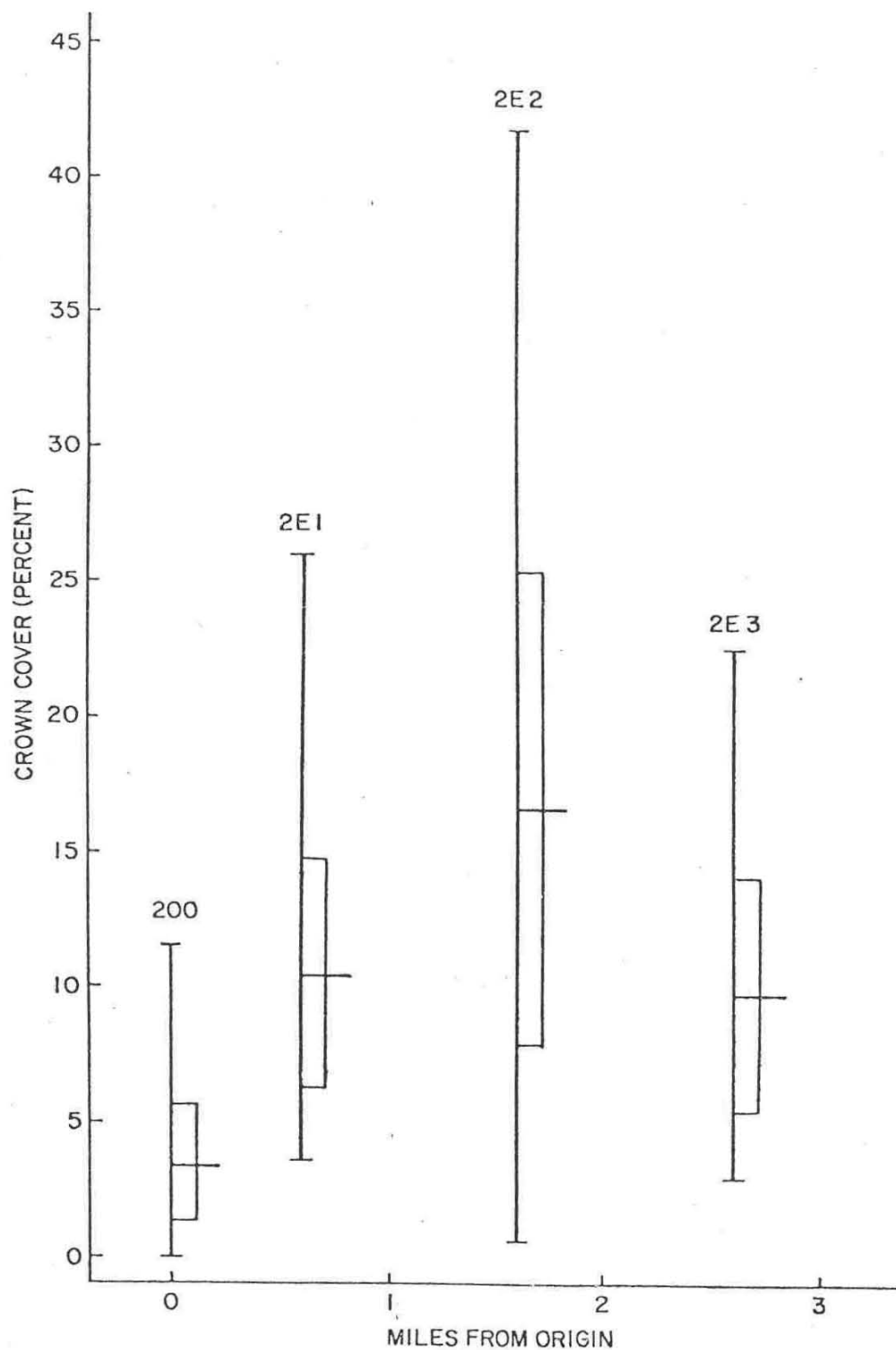


Fig. 18. Mean, range and 95% confidence interval of perennial plant cover in study plots along transect no. 2, Aguajita Spring. Cover in plot 200 is significantly lower ($P < 0.05$) than in plots 2E1 and 2E2. Statistics in Appendix III.

Table 8. Perennial plant density and cover in plot No. 200, Aguajita Spring.

Species	Density (no./0.1 ha)	Cover (%)
1. <u>Suaeda torreyana</u>	226	3.09
2. <u>Atriplex linearis</u>	50	0.09
3. <u>Atriplex polycarpa</u>	17	0.25
4. <u>Larrea divaricata</u>	1	
5. <u>Ambrosia deltoidea</u>	1	
Total	295	3.43

along transect no. 2 may be due to corresponding differences in soil characteristics (Tables 9-11). However, total soluble salt concentrations in surface soil samples show that salinity is not excessively high and is actually lower at the origin than at other plots along the transect (Appendix VI). Soil structure changes along the transect, with a larger proportion of cobbles at plots more distant from the origin. Vegetation differences may be a result of such differences in soil structure.

Only one species, seep-weed, decreases in abundance with increasing distance from the transect' origin. Other species occurring along the transect are either absent at the origin, or occur at the origin but increase in abundance with distance from Aguajita Spring (Tables 8-11). Creosotebush (Larrea divaricata) and triangle bur-sage (Ambrosia deltoidea), both uncommon at the origin, occur as dominants in all other plots along the transect. Two other shrub species that occur in relative abundance near the end of the transect, white bur-sage (Ambrosia dumosa) and white ratany (Krameria grayi), are absent at the origin.

Other important members of the community are gees and cacti. Although these species occur in relatively low densities, their growth form makes a major contribution to the physiognomy of the vegetation. Due to their typically low densities, however, tree species may be absent from a sample plot even though they are a characteristic member of the community. For example, mesquite (Prosopis juliflora) which occurs all along the transect, is absent from plot no. 1 despite its general abundance in the area.

In the vicinity of Aguajita Spring mesquite shows considerable hedging due to browsing (Fig. 19). The area immediately beneath the canopy of trees is severely trampled by browsing and shade-seeking cattle. In contrast, mesquites at sites removed from Aguajita Spring often have an accumulation of fallen branches immediately beneath the canopy.

Table 9. Perennial plant density and cover in plot No. 2E1, Aguajita Spring.

Species	Density	Cover (no./0.1 ha)
1. <u>Atriplex polycarpa</u>	137	4.80
2. <u>Atriplex linearis</u>	90	1.34
3. <u>Ambrosia deltoidea</u>	33	2.41
4. <u>Larrea divaricata</u>	17	0.98
5. <u>Suaeda torreyana</u>	11	0.98
6. <u>Opuntia stanlyi</u>	2	
7. <u>Opuntia fulgida</u>	2	
8. <u>Opuntia leptocaulis</u>	2	
9. <u>Echinocereus engelmanni</u>	1	
10. <u>Ambrosia dumosa</u>	1	
11. <u>Lycium andersoni</u>	1	
12. <u>Olynea tesota</u>	1	
13. <u>Prosopis juliflora</u>	1	
Total	299	10.51

Table 10. Perennial plant density and cover in plot No. 2E2, Aguajita Spring.

	Species	Density no./0.1 ha)	Cover (%)
1.	<u>Atriplex polycarpa</u>	54	0.98
2.	<u>Atriplex linearis</u>	73	1.02
3.	<u>Ambrosia deltoidea</u>	149	1.91
4.	<u>Larrea divaricata</u>	54	6.84
5.	<u>Ambrosia dumosa</u>	82	0.64
6.	<u>Opuntia stanlyi</u>	6	0.27
7.	<u>Olneya tesota</u>	2	2.32
8.	<u>Cercidium microphyllum</u>	2	1.86
9.	<u>Fouquieria splendens</u>	1	0.80
10.	<u>Mammillaria microcarpa</u>	1	
	Total	424	16.64

Table 11. Perennial plant density and cover in plot No. 2E3, Aguajita Spring.

	Species	Density (no./0.1 ha)	Cover (q)
1.	<u>Atriplex polycarpa</u>	113	4.75
2.	<u>Atriplex linearis</u>	114	1.43
3.	<u>Larrea divaricata</u>	24	1.61
4.	<u>Ambrosia dumosa</u>	40	0.73
5.	<u>Prosopis juliflora</u>	2	1.23
6.	<u>Ambrosia deltoidea</u>	3	
7.	<u>Krameria rayi</u>	8	
8.	<u>Echinocactus engelmanni</u>	2	
9.	<u>Mammillaria microcarpa</u>	3	
10.	<u>Opuntia stanlyi</u>	1	
11.	<u>Cereus greggi</u>	1	
	Total	312	9.75

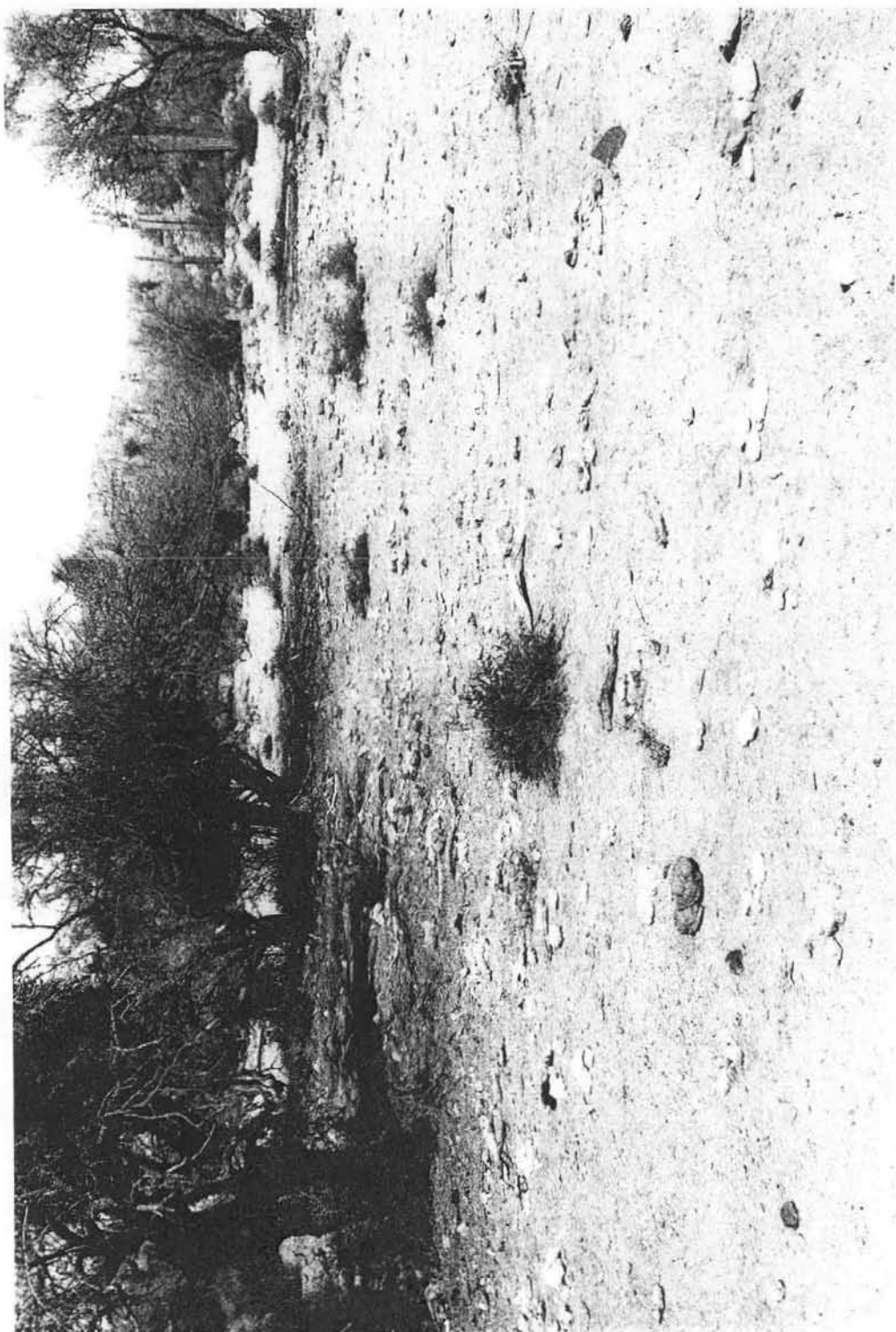


Fig. 19. Mesquite (*Prosopis juliflora*) near Aguajita Spring damaged by browsing and shade-seeking livestock. The area beneath the tree canopies is barren and trampled. Photographed 6 February 1976.

Six species of cacti occur along transect no. 2: jumping cholla (Opuntia fulgida), Christmas cactus (O. leptocaulis), devil cholla (O. stanlyi), nightblooming cereus (Cereus greggi), hedgehog cactus (Echinocereus engelmanni), and pincushion cactus (Mammillaria microcarpa). Of these, three species--Christmas cactus, nightblooming cereus and pincushion cactus--are generally found only under the protective canopy of shrubs or trees. The occurrence of these cacti along transect no. 2 is associated with increased perennial plant cover, which protective habitat for these species.

Rodents.--Rodent species diversity along transect no. 2 increases with plant species diversity (compare Tables 7 and 12). The lowest rodent species diversity was found at plot 200 containing the smallest number of plant species. The rodent community at this plot is dominated by Merriam's kangaroo rat (Dipodomys merriami). A few desert pocket mice (Perognathus penicillatus) are also present. Merriam's kangaroo rat and the desert pocket mouse are the dominant members of the rodent community throughout the length of the transect. As one moves away from the origin and plant diversity increases, however, several additional species occur. These species include the Arizona pocket mouse (P. amplus), Bailey's pocket mouse (P. baileyi), the white-throated woodrat (Neotoma albigula), and the southern grasshopper mouse (Onychomys torridus). Bailey's pocket mouse is commonly associated with rocky soils and its occurrence is attributed to the increasing abundance of cobbles in the soil as one moves away from the transect origin (Appendix VI). The other additional species, particularly the Arizona pocket mouse and white-throated woodrat, require a habitat with more protective vegetation cover than Merriam's kangaroo rat and the desert pocket mouse. Their occurrence on plots more

Table 12. Population data for rodents along Transect No. 2, AguaJita Spring. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectares. Relative abundance is calculated from density estimate figures. Trapping was carried out during February and May 1976.

Species	Plot 200			Plot 2E1			Plot 2E2		
	captures	density	rel. abund.	captures	density	rel. abund.	captures	density	rel. abund.
<u>Dipodomys merriami</u>	20.0	12	0.71	6.0	4	0.33	9.0	12	0.35
<u>Perognathus penicillatus</u>	4.0	5	0.29	5.0	5	0.42	4.8	10	0.29
<u>Perognathus amplus</u>	--	--	--	1.0	2	0.17	2.1	5	0.15
<u>Perognathus baileyi</u>	--	--	--	--	--	--	0.5	2	0.06
<u>Neotoma albigula</u>	--	--	--	--	--	--	2.1	5	0.15
<u>Onychomys torridus</u>	--	--	--	1.0	1	0.08	--	--	--
Total	24.0	17	1.00	13.0	12	1.00	18.5	34	1.00
Species diversity (H')	0.262			0.536			0.636		
Total trap nights	100			100			188		

Table 12. Continued.

Species	Plot 2E3		
	captures	density	rel. abun.
<u>Dipodomys merriami</u>	4.9	6	0.46
<u>Perognathus penicillatus</u>	3.9	5	0.39
<u>Perognathus amplus</u>	1.0	2	0.15
<u>Perognathus baileyi</u>	--	--	--
<u>Neotoma albigula</u>	--	--	--
<u>Onychomys torridus</u>	--	--	--
Total	9.8	13	1.00
Species diversity (H')		0.438	
Total trap nights		102	

distant from Aguajita Spring is attributed to the greater vegetation cover in those plots (Wondolleck 1975, Price 1976).

Transect No. 3, Ajo Mountains

Vegetation.--Important changes in the vegetation of transect no. 3 occur with increasing distance from the origin at the mouth of Alamo Canyon (Figs. 2, 20). Although an overall downward trend in species abundance was noted, species diversity increases dramatically along the transect and maintains values consistently higher than those for any other part of the monument sampled in this study (Table 13).

The low species diversity at the transect origin (plot 300) is the result of a relatively high density of triangle bur-sage (Ambrosia deltoidea), especially young individuals (Fig. 21). The exceptional local abundance of this species effectively reduces the relative importance of all other species. Plots 3S2 and 3S3 have numbers of species that are less than or nearly equal to plot 300. However, they have a much higher species diversity because there is a more equitable relative abundance of the dominant species on these plots. Similar results were obtained by Blydenstein et al. (1957) who reported higher densities of triangle bur-sage in areas subject to grazing pressure as compared to areas protected from such disturbance.

The lack of any consistent relationship between total plant density and cover seen by comparison of figures 22 and 23 is a result of between plot differences in species composition. Large order differences between plots in the relative importance of the four principal shrub species (Ambrosia deltoidea, Larrea divaricata, Encelia farinosa, and Simmondsia chinensis) evident by comparison of their density and cover shown in tables 14-18. It is likely that much of

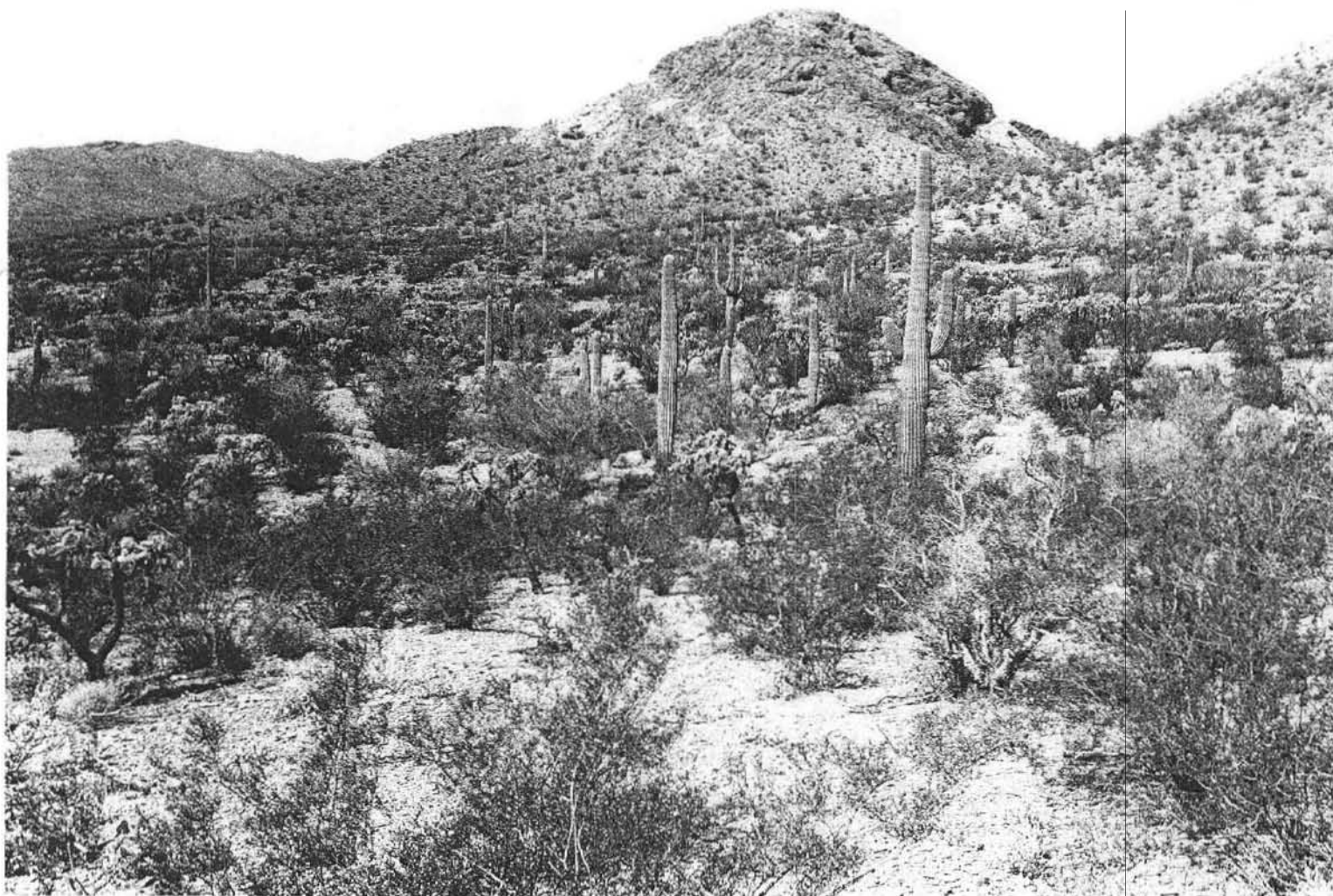


Fig. 20. Plot 3S1, Ajo Mountains. Dominant species in foreground are creosotebush (Larrea divaricata) and foothill paloverde (Cercidium microphyllum). Cacti are jumping cholla (Opuntia fulgida) and saguaro (Cereus giganteus). Photographed 8 February 1975.

Table 13. Number of perennial plant species and perennial plant diversity estimated by the Shannon-Wiener index (H') along Transect No. 3, Ajo Mountains.

Plot	No. of Species	Species diversity (H')
300	19	0.158
3S1	26	0.909
3S2	20	0.828
3S3	15	0.752
3S4	24	0.671

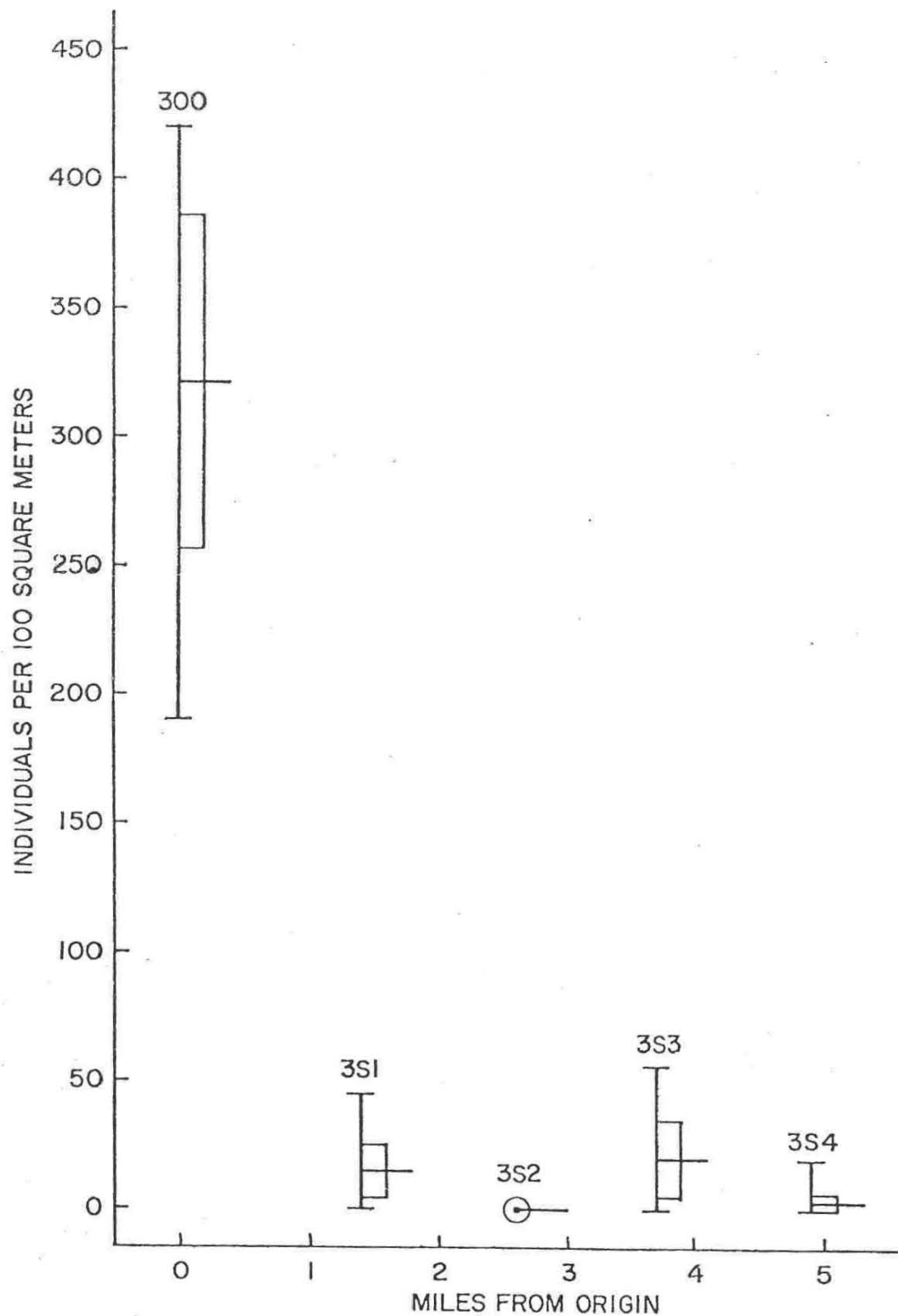


Fig. 21. Mean, range and 95% confidence interval of triangle bur-sage (*Ambrosia deltoidea*) density in plots along transect no. 3, Ajo Mountains. High density of triangle bur-sage in plot 300 results from the presence of large numbers of young individuals.

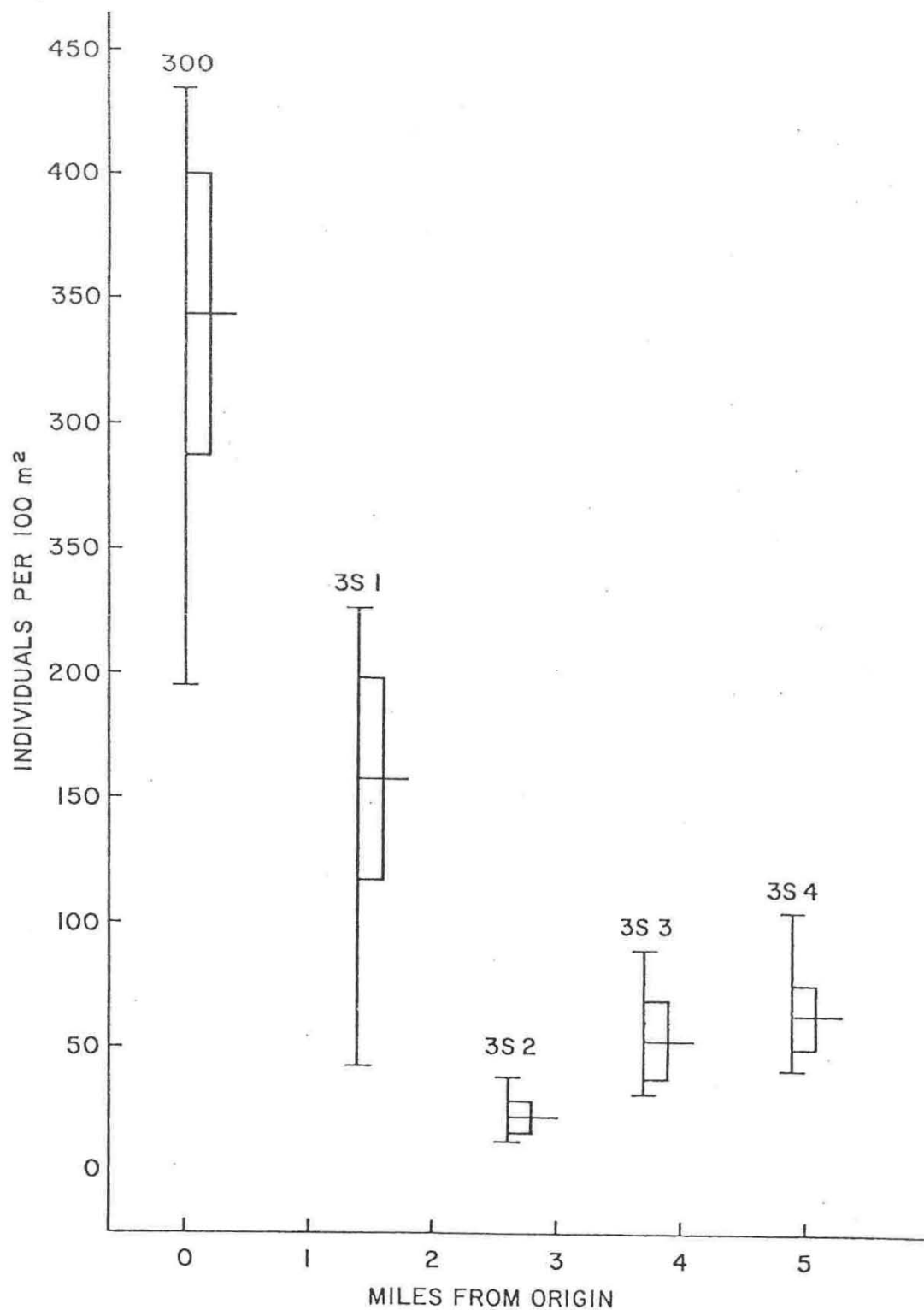


Fig. 22. Mean, range and 95% confidence interval of perennial plant density in plots along transect no. 3. Significant differences in total plant density occur in plots 300, 3S1, and 3S2 ($P < 0.05$). Statistics in Appendix III.

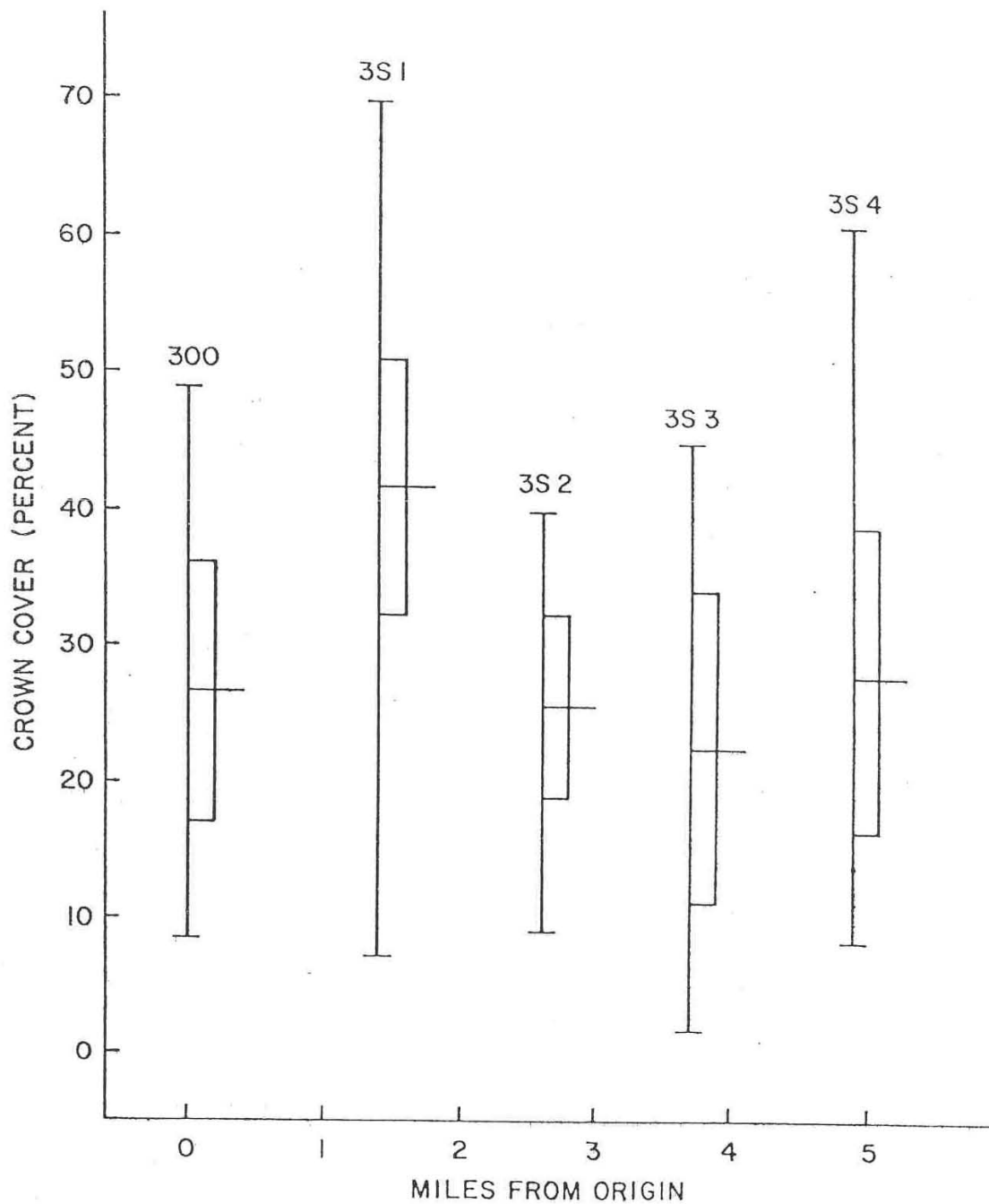


Fig. 23. Mean, range and 95% confidence interval of perennial plant cover in plots along transect no. 3. Statistics in Appendix III.

Table 14. Perennial plant density and cover in plot No. 300, Alamo Canyon.

	Species	Density	Cover
		(no./0.1 a)	%
1.	<u>Larrea divaricata</u>	36	8.07
2.	<u>Ambrosia deltoidea</u>	3217	11.29
3.	<u>Cassia covesi</u>	71	
4.	<u>Opuntia acanthocarpa</u>	36	2.57
5.	<u>Psilostrophe cooperi</u>	18	
6.	<u>Opuntia fulgida</u>	11	1.23
7.	<u>Olneya tesota</u>	8	2.57
8.	<u>Cereus giganteus</u>	8	
9.	<u>Janusia gracilis</u>	7	
10.	<u>Lycium andersoni</u>	8	0.77
11.	<u>Encelia farinosa</u>	3	0.14
12.	<u>Opuntia leptocaulis</u>	3	
13.	<u>Prosopis juliflora</u>	3	
14.	<u>Mammillaria microcarpa</u>	3	
15.	<u>Simmondsia chinensis</u>	3	
16.	<u>Acacia greggi</u>	1	
17.	<u>Cercidium microphyllum</u>	1	
18.	<u>Krameria grayi</u>	1	
19.	<u>Opuntia phaeacantha</u>	1	
	Total	3439	27.64
		60	

Table 15. Perennial plant density and cover in plot No. 3S1, Alamo Canyon.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Encelia farinosa</u>	643	9.39
2. <u>Larrea divaricata</u>	160	19.55
3. <u>Ambrosia deltoidea</u>	146	2.32
4. <u>Psilostrophe cooperi</u>	101	0.36
5. <u>Janusia gracilis</u>	57	0.23
6. <u>Lycium andersoni</u>	24	0.95
7. <u>Opuntia fulgida</u>	21	0.59
8. <u>Opuntia acanthocarpa</u>	13	1.36
9. <u>Cereus giganteus</u>	9	0.32
10. <u>Hibiscus coulteri</u>	10	0.11
11. <u>Cercidium microphyllum</u>	8	5.00
12. <u>Simmondsia chinensis</u>	36	0.09
13. <u>Jatropha cardiophylla</u>	6	0.73
14. <u>Bouteloua</u> sp.	207	0.02
15. <u>Prosopis juliflora</u>	1	0.34
16. <u>Allionia incarnata</u>	44	
17. <u>Cassia covesi</u>	24	
18. <u>Dalea</u> sp.	17	
19. <u>Abutilon</u> sp.	16	
20. <u>Ditaxis lanceolata</u>	11	

Table 15. Continued.

	Species	Density	Cover
		(no./0.1 ha)	%
21.	<u>Ayenia pusilla</u>	7	
22.	<u>Lyrocarpa coulteri</u>	5	
23.	<u>Euphorbia albomarginata</u>	3	
24.	<u>Mammillaria microcarpa</u>	3	
25.	<u>Calliandra eriophylla</u>		
26.	<u>Echinocereus engelmanni</u>	2	
	Total	1576	41.36

Table 16. Perennial plant density and cover in plot No. 3S2, Arch Canyon.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Larrea divaricata</u>	114	22.55
2. <u>Encelia farinosa</u>	44	0.71
3. <u>Simmondsia chinensis</u>	18	0.80
4. <u>Krameria g rayi</u>	16	0.11
5. <u>Opuntia acanthocarpa</u>	8	0.30
6. <u>Cereus giganteus</u>	8	0.09
7. <u>Echinocereus engelmanni</u>	8	0.04
8. <u>Cereus thurberi</u>	1	0.59
9. <u>Cercidium microphyllum</u>	1	0.23
10. <u>Opuntia fulgida</u>	6	
11. <u>Psilostrophe cooperi</u>	4	
12. <u>Lycium andersoni</u>	4	
13. <u>Cassia covesi</u>	3	
14. <u>Mammillaria microcarpa</u>	3	
15. <u>Fouquieria splendens</u>	2	
16. <u>Ambrosia deltoidea</u>	1	
17. <u>Janusia gracilis</u>	1	
18. <u>Jatropha cardiophylla</u>	1	
19. <u>Opuntia phaeacantha</u>	1	
20. Unknown	1	
Total	244	25.51

Table 17. Perennial plant density and cover *in* plot No. 3S3, Estes Canyon.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Larrea divaricata</u>	146	16.55
2. <u>Ambrosia deltoidea</u>	186	3.23
3. <u>Psilostrophe cooperi</u>	95	0.84
4. <u>Krameria grayi</u>	51	0.20
5. <u>Simmondsia chinensis</u>	13	0.32
6. <u>Prosopis juliflora</u>	10	0.23
7. <u>Opuntia phaeacantha</u>	6	0.68
8. <u>Cereus giganteus</u>	4	0.16
9. <u>Lycium andersoni</u>	4	0.25
10. <u>Opuntia acanthocarpa</u>	10	
11. <u>Cassia covesi</u>		
12. <u>Echinocereus engelmanni</u>	3	
13. <u>Cercidium microphyllum</u>	2	
14. <u>Mammillaria microcarpa</u>	2	
15. <u>Opuntia leptocaulis</u>	1	
Total	536	22.46

Table 18. Perennial plant density and cover in plot No. 3S4, Estes Canyon.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Encelia farinosa</u>	414	13.50
2. <u>Simmondsia chinensis</u>	50	4.64
3. <u>Ambrosia deltoidea</u>	22	1.14
4. <u>Opuntia fulgida</u>	14	0.55
5. <u>Abutilon</u> sp.	13	0.14
6. <u>Cercidium microphyllum</u>	9	6.52
7. <u>Jatropha cardipptiylla.</u>	8	0.05
8. <u>Lycium andersoni</u>	7	0.49
9. <u>Olneya tesota</u>	1	0.23
10. <u>Larrea divaricata</u>	1	0.16
11. <u>Atriplex linearis</u>	2	0.07
12. <u>Janusia gracilis</u>	17	
13. <u>Siphonoglossa longiflora</u>	14	
111 <u>Cassia covesi</u>	10	
15. <u>Lyrocarpa coulteri</u>	9	
16. <u>Allionia incarnata</u>	9	
17. <u>Opuntia acanthocarpa</u>	7	
18. <u>Mammillaria microcarpa</u>	4	
19. <u>Calliandra eriophylla</u>	3	
20. <u>Krameria grayi</u>	3	

Table 18. Continued.

	Species	Density	Cover
		(no./0.1 ha)	%
21.	<u>Cereus thurberi</u>		
22.	<u>Cereus giganteus</u>	1	
23.	<u>Coursettia glandulosa</u>	1	
24.	Unidentified (<u>Compositae</u>)	9	0.25
	Total	629	27.74

the observed variation in species composition along this transect is attributable to edaphic and topographic factors.

The vegetation sampled by transect no. 3 is dominated numerically by shrubs, but the general aspect of the upper bajada vegetation is dominated by trees and larger cacti. Of these groups shrubs revealed the clearest patterns of abundance along the transect. Jojoba (Simmondsia chinensis), a shrub of primary importance as a browse plant, showed the greatest increase in density and cover along the transect. Very sparse at plot 300, it increases in abundance along the transect to a position of dominance at the end, surpassed in density and abundance only by brittlebush (Encelia farinosa) in plot 3S4. Paralleling its increase in importance in the community, the mean size of the individual jojoba plants also increased with distance from the transect origin (Table 19). The stunted stature of jojoba at the transect origin is a result of heavy grazing pressure. At the mouth of Alamo Canyon, the only jojoba individuals approaching the size typical of specimens in undisturbed areas are those growing within the protective canopy of a larger shrub, tree, or cactus (Figs. 24, 25).

White ratany (Krameria grayi), another important browse species, also shows a trend toward increasing abundance along transect no. 3. It is absent or uncommon in plots 300 and 3S1, increasing to a position of importance in plots 3S2 and 3S3.

No major differences in abundance of cacti were found along transect no. 3. Large cacti which are characteristic members of the community, such as jumping cholla (Opuntia fulgida), staghorn cholla (O. acanthocarpa) and saguaro (Cereus giganteus) occur in moderate densities in most plots. A slight decrease in density of cacti occurs as one moves away from Alamo Canyon. The less abundant cactus species, such as Christmas cactus (O. leptocaulis), pincushion cactus (Mammillaria microcarpa), prickly-pear cactus (O.

Table 19. Height (cm) of jojoba (Simmondsia chinensis) along Transect No. 3, Ajo

Mountains. Some measurements were made off-plot to increase sample size.

Plot	N	Mean (t SE)	Range
300	30	33.50 ± 3.51	13 - 76
3S1	35	34.50 t 2.96	8-77
3S2	25	46.30 t 5.51	12 - 138
3S3	29	42.80 t 3.04	13 - 82
3S4	35	65.34 t 5.03	18 - 158

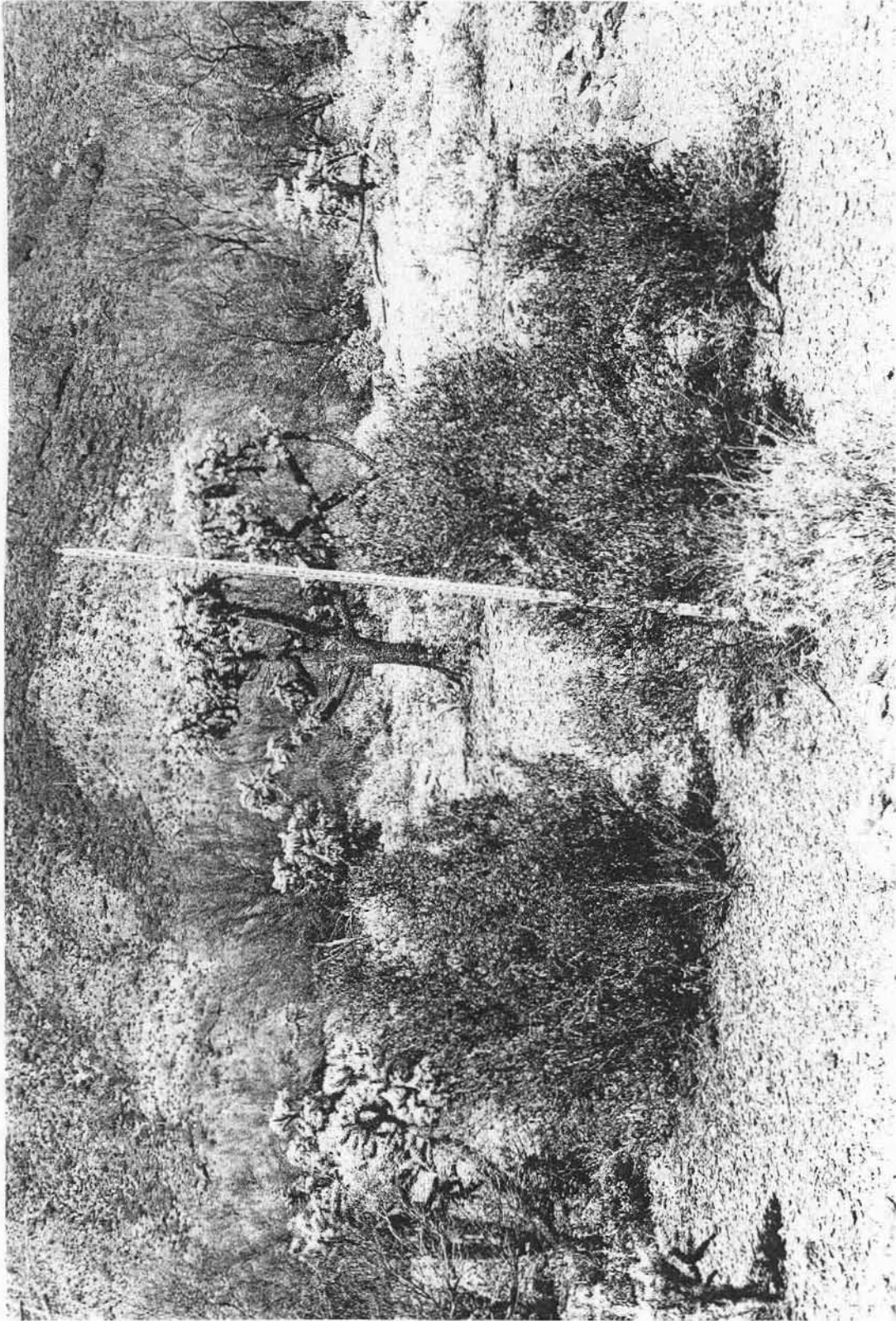


Fig. 24. Jojoba (Simmondsia chinensis) growing in a relatively undisturbed site near Grass Canyon.
Photographed 2 May 1976.

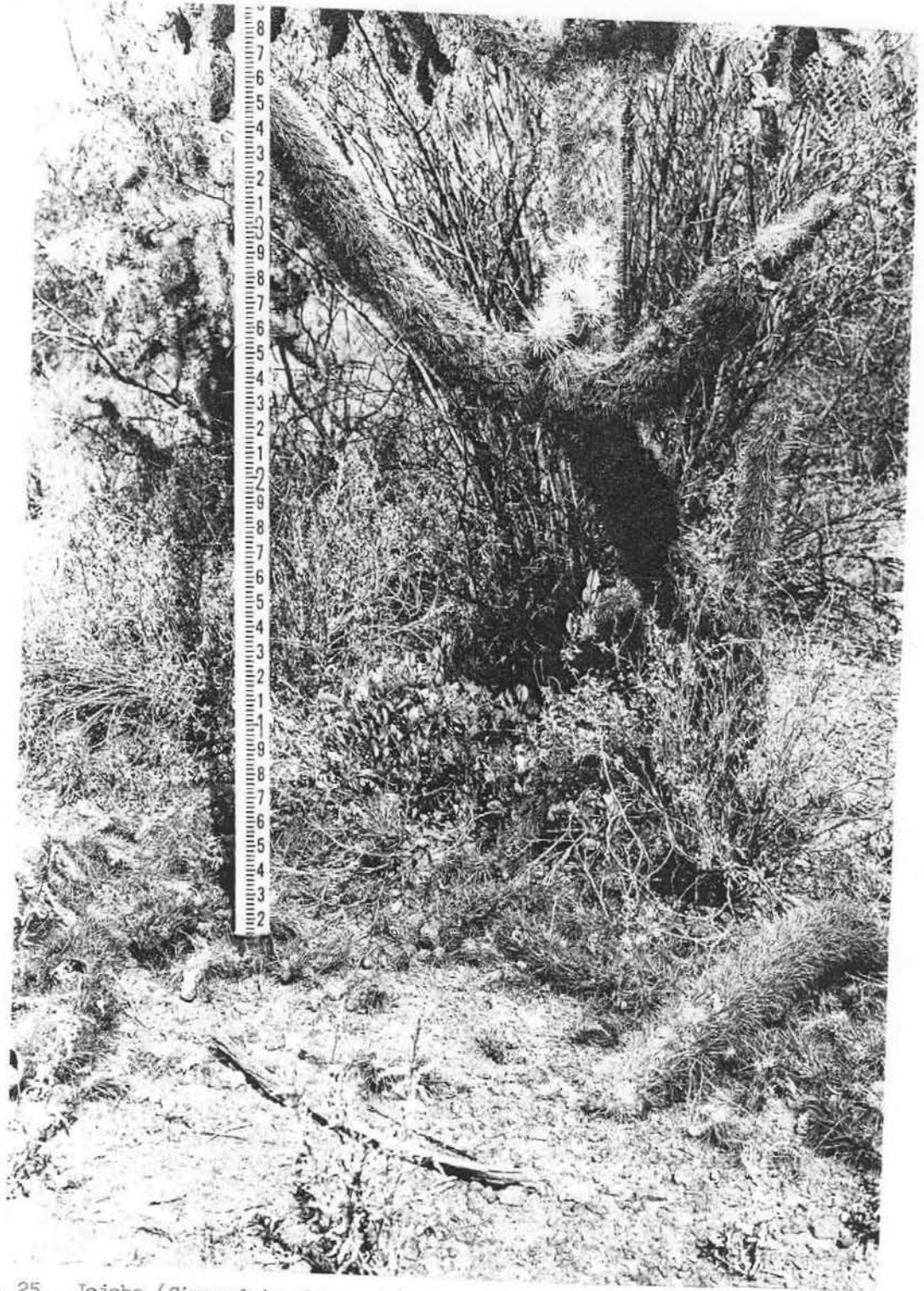


Fig. 25. Jojoba (*Simmondsia chinensis*) in an area heavily used by livestock near the mouth of Alamo Canyon. Individuals are severely browsed and grow almost exclusively under the protective cover of other less palatable species such as the cholla cactus shown here. Photographed 20 June 1976.

phaeacantha), hedge hog cactus (Echinocereus engelmanni) and organpipe cactus (Cereus thurberi), occur sporadically along the transect.

Five suffrutescent perennial plant species which generally grow under the protective canopy of larger plants are found along transect no. 3. These are Janusia gracilis, rose-mallow (hibiscus coulteri), Ayenia pusilla, lyre pod (Lyrocarpa coulteri) and Siphonoglossa longiflora. The association of these species with high plant cover and density in plots 3S1 and 3S4 is noteworthy. These highly sensitive species occur sparsely or not at all in heavily grazed and less densely vegetated plots.

Rodents.--Rodent populations were similar in all plots along transect no. 3 ([Table 20](#)). Large seasonal differences were noted in populations of the two dominant species, Bailey's pocket mouse (Perognathus baileyi) and the cactus mouse (Peromyscus eremicus) ([Table 21](#)). The differences in rodent population between transect no. 3 and lower sites such as Growler Valley reflect two important differences between the upper bajada and the lower bajada habitats. The increasing rockiness of the upper bajada soil and the greater plant cover serve to exclude Merriam's kangaroo rat which requires fine-textured soil and open vegetation (Bartholomew and Caswell 1951). Unlike Merriam's kangaroo rat, Bailey's pocket mouse is generally associated with rocky soils and is found in peak densities on the rocky upper bajadas. Cactus mice, which are not capable of jumping and digging as are kangaroo rats and pocket mice, are restricted to areas of protective plant cover and therefore have larger populations on the upper bajada (Lewis 1972).

Other less common rodents captured along transect no. 3 are the white-throated woodrat (Neotoma albigula), Merriam's kangaroo rat (Dipodomys merriami), and the

Table 20. Population data for rodents along Transect No. 3, Ajo Mountains. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectare. Relative abundance is calculated from density estimate figures. Trapping was carried out during February and June 1976.

Species	Plot 300			Plot 3S1			Plot 3S2		
	captures	density	rel. abund.	captures	density	rel. abund.	captures	density	rel. abund.
<u>Perognathus baileyi</u>	16.7	20	0.87	36.8	37	0.95	21.7	30	0.86
<u>Peromyscus eremicus</u>	0.9	2	0.09	1.3	2	0.05	1.9	4	0.11
<u>Neotoma albigula</u>	0.4	1	0.04	--	--	--	--	--	--
<u>Dipodomys merriami</u>	--	--	--	--	--	--	0.5	1	0.03
<u>Perognathus penicillatus</u>	--	--	--	--	--	--	--	--	--
Total	18.0	23	1.00	38.1	39	1.00	24.1	35	1.00
Species diversity (H')	0.203			0.086			0.207		
Total trap nights	233			152			212		

Table 20. Continued.

Species	Plot 3S3			Plot 3S4		
	captures	density	rel. abund.	captures	density	rel. abund.
<u>Perognathus baileyi</u>	16.2	20	0.87	12.2	10	0.64
<u>Peromyscus eremicus</u>	0.6	1	0.04	1.7	2	0.12
<u>Neotoma albigula</u>	--	--	--	1.1	2	0.12
<u>Dipodomys merriami</u>	2.3	2	0.09	--	--	--
<u>Perognathus penicillatus</u>	--	--	--	1.7	2	0.12
Total	19.1	23	1.00	16.7	16	1.00
Species diversity (H')	0.203			0.456		
Total trap nights	173			181		

Table 21.. Seasonal activity (number/100 trap nights) of the common rodents along Transect No.

3, Ajo Mountains, June 1975-February 1976.

Species	June	July	November	February
<u>Perognathus baileyi</u>	25.8	21.2	3.5	6.9
<u>Peromyscus eremicus</u>	0.2	--	1.8	4.3
Dipodomys <u>merriami</u>	0.3	--	1.8	0.9
Total	26.3	21.2	7.1	12.1

desert pocket mouse (Perognathus penicillatus). In spite of their infrequent occurrence, the less common rodents tend to occur more frequently at sites distant from the origin, resulting in a general pattern of increasing rodent diversity with increasing distance from Alamo Canyon (Table 20).

Transect No. 4, Senita Basin

Vegetation.--The Senita Basin sample transect does not represent an experimental treatment comparable with that used at other study sites. There, a situation of high local livestock use intensity does not exist due to the absence of livestock watering facilities. However, Senita Basin is sufficiently interesting from a floristic point of view to justify obtaining a quantitative vegetation record from the area.

The vegetation in Senita Basin is, in some respects, among the most diverse of any sampled in the monument (Table 22). Although a greater number of species and higher species diversity values were found along transect no.3 near the Ajo Mountains, Senita Basin is unique among the study sites for its abundance of arborescent species (Figs. 3, 26, 27). Density and cover values are also higher than those obtained from any other study site except some plots along transect no. 3 (Figs. 28, 29).

The numerically dominant shrub species in Senita Basin are the same as those found in many other parts of the monument Creosotebush (Larrea divaricata) and triangle bur-sage (Ambrosia deltoidea) are the two most abundant shrubs. They also constitute the greatest portion of perennial plant cover (Tables 23-25). Other shrub species of widespread

Table 22. Number of perennial plant species and perennial plant species diversity estimated by the Shannon-Wiener index (H') along Transect No. 4, Senita. Basin.

Plot	. of species	Species diversity (H')
400	22	0.455
Owl	12	0.368
4w2	19	0.525



Fig. 26. Plot 4W1, Senita Basin. Species in the foreground are ocotillo (Fouquieria splendens) at left, senita (Cereus schottii) at right, and triangle bur-sage (Ambrosia deltoidea). Photographed 8 February 1975.

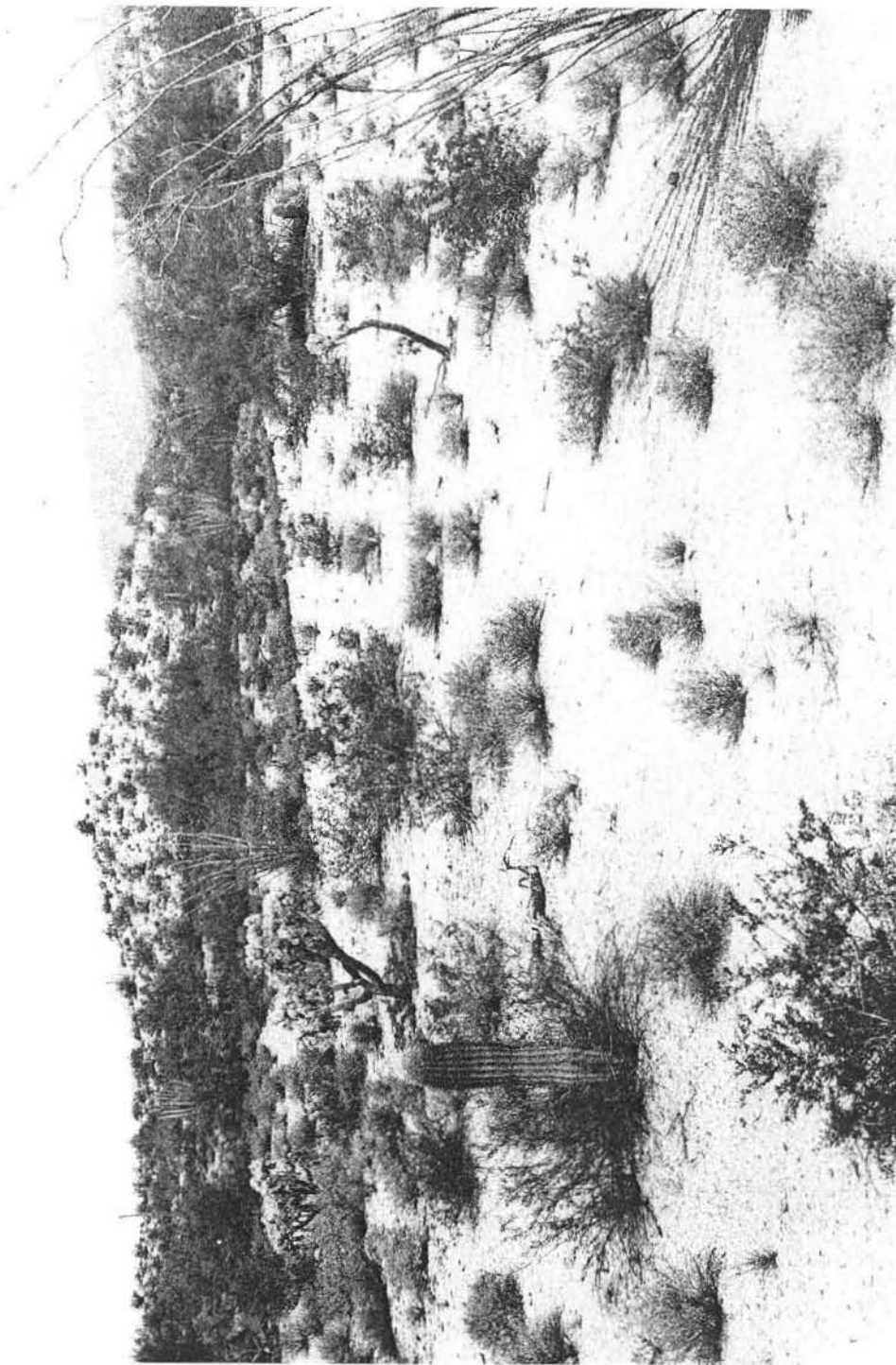


Fig. 27. Plot 4W2, Senita Basin. Species in the foreground are creosotebush (*Larrea divaricata*), triangle bur-sage (*Ambrosia deltoidea*), and ocotillo (*Fouquieria splendens*). Limerbush (*Jatropha cardiophylla*) occurs in the small wash crossing diagonally to the left. Photographed 8 February 1975.

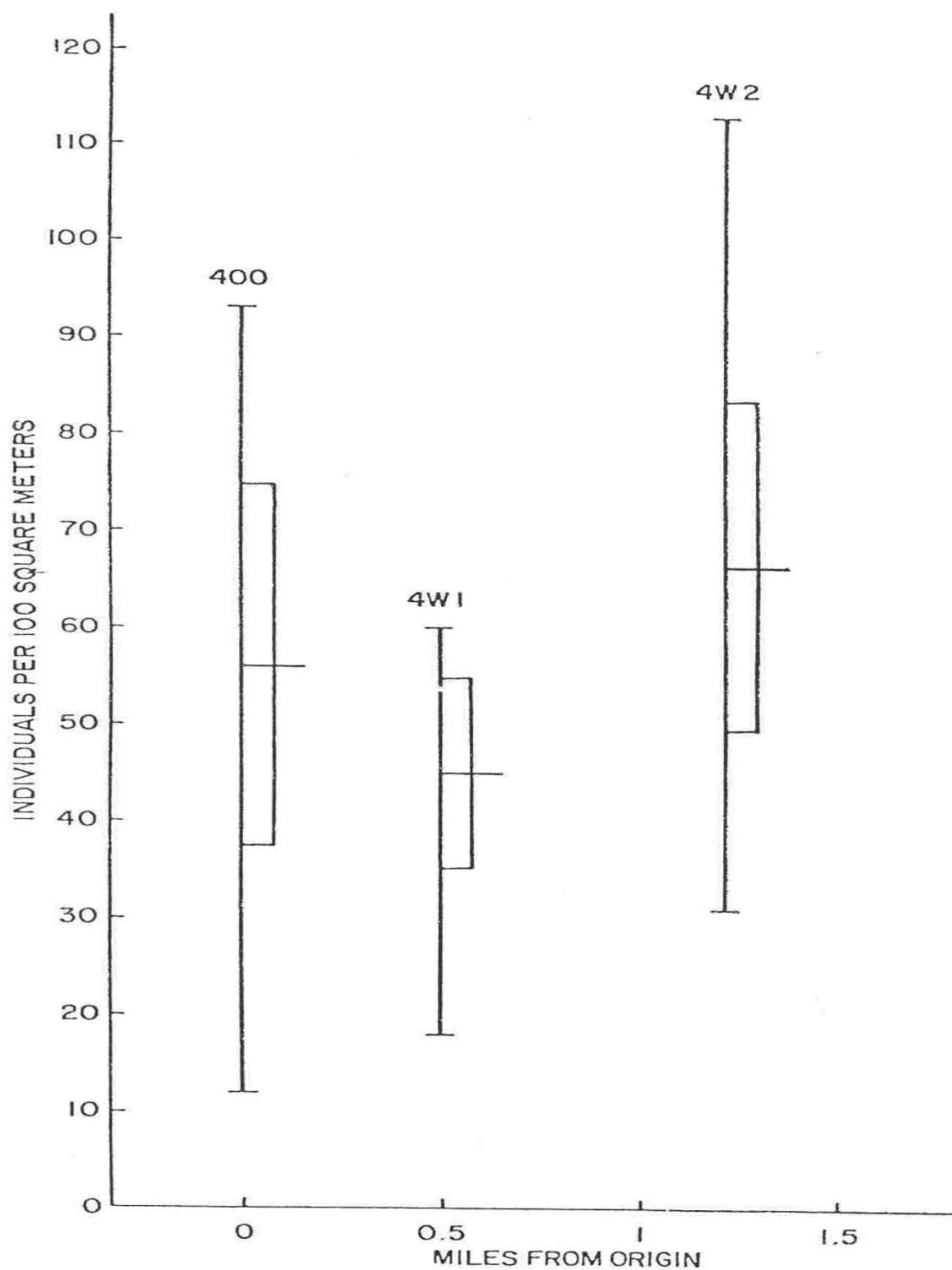


Fig. 28. Mean, range and 95% confidence interval of perennial plant density in plots along transect no. 4, Senio Basin. Statistics in Appendix III.

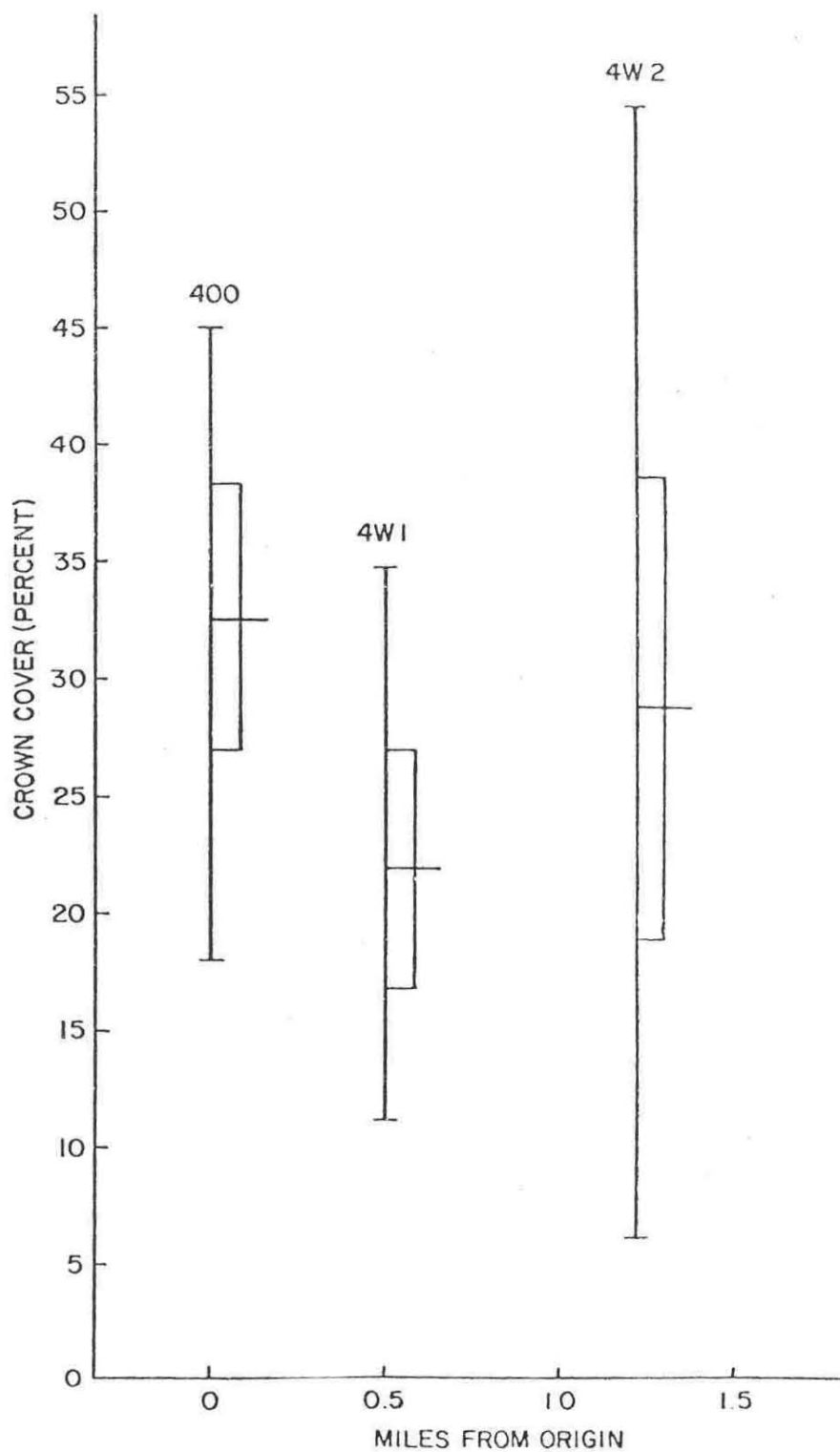


Fig. 29. Mean, range and 95% confidence interval of perennial plant cover in plots along transect no. 4, Senita Basin. Statistics in Appendix III.

Table 23. Perennial plant density and cover in plot No. 400, Senita Basin.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Ambrosia deltoidea</u>	446	15.23
2. <u>Larrea divaricata</u>	31	4.91
3. <u>Opuntia fulgida</u>	16	0.21
4. <u>Ambrosia ambrosioides</u>	7	1.77
5. <u>Olneya tesota</u>	3	3.05
6. <u>Fouquieria splendens</u>	6	0.96
7. <u>Cereus thurberi</u>	3	¹ 2.3
8. <u>Cereus giganteus</u>	7	0.09
9. <u>Lycium andersoni</u>	6	0.91
10. <u>Hyptis emoryi</u>	5	0.73
11. <u>Prosopis juliflora</u>	2	1.05
12. <u>Acacia constricta</u>	1	1.50
13. <u>Cereus schotti</u>	2	0.48
14. <u>Abutilon</u> sp.	1	0.46
15. <u>Cercidium microphyllum</u>	2	0.14
16. <u>Mammillaria microcarpa</u>	8	
17. <u>Encelia farinosa</u>	6	
18. <u>Jatropha cardiophylla</u>	2	
19. <u>Acacia greggi</u>	2	
20. <u>Sapium biloculare</u>	2	
21. <u>Ferocactus wislizeni</u>	1	
22. Unknown		
Total	560	32.72

Table 24. Perennial plant density and cover in plot No. 4W1, Senita Basin

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Ambrosia deltoidea</u>	330	10.36
2. <u>Larrea divaricata</u>	89	8.50
3. <u>Cereus schotti</u>	4	1.75
4. <u>Fouquieria splendens</u>	7	0.36
5. <u>Cereus giganteus</u>	6	0.21
6. <u>Jatropha cardiophylla</u>	2	0.68
7. <u>Opuntia fulgida</u>	4	
8. <u>Jatropha cinerea</u>	2	
9. <u>Mammillaria microcarpa</u>	2	
10. <u>Cereus thurberi</u>	1	
11. <u>Encelia farinosa</u>	1	
12. <u>Echinocereus engelmanni</u>	1	
Total	449	21.86

Table 25. Perennial plant density and cover in plot No. 4W2, Senita Basin.

Species	Density	Cover
	(no./0.1 ha)	%
1. <u>Ambrosia deltoidea</u>	473	13.11
2. <u>Larrea divaricata</u>	58	4.64
3. <u>Cercidium microphyllum</u>	7	7.98
4. <u>Encelia farinosa</u>	54	1.14
5. <u>Opuntia fulgida</u>	5	0,89
6. <u>Krameria grayi</u>	10	0.32
7. <u>Ambrosia dumosa</u>	2	0.16
8. <u>Lyrocarpa coulteri</u>	30	
9. <u>Jatropha cardiophylla</u>	8	
10. <u>Psilostrophe cooperi</u>	9	
11. <u>Opuntia acanthocarpa</u>	3	
12. <u>Cereus giganteus</u>	3	
13. <u>Fouguieria splendens</u>	3	
14. <u>Mammillaria microcarpa</u>	3	
15. <u>Lycium andersoni</u>	2	
16. <u>Calliandra eriophylla</u>	1	
17. <u>Sapium biloculare</u>	1	
18. <u>Echinocereus engelmanni</u>	1	
19. Unknown	2	
Total	675	28.24

occurrence such as brittlebush (Encelia farinosa), wolfberry (Lycium andersoni), and white ratany (Krameria grayi) make an important contribution to the total shrub density. Three species, desert lavender (Hyptis emoryi), whitethorn (Acacia constricta), and catclaw (A. greggi) are predominantly "desert riparian" species in Organ Pipe Cactus National Monument and their occurrence in plot 400 is associated with the wash which crosses one end of the plot.

Among the arborescent members of the plant community in Senita Basin, several are common trees of the Sonoran Desert. These include ironwood (Olneya tesota), mesquite (Prosopis juliflora), and foothill paloverde (Cercidium microphyllum). In addition to the typical tree species, three arborescent cacti, senita (Cereus schotti), organpipe (Cereus thurberi), and saguaro (Cereus giganteus) give Senita Basin an aspect unusual for southern Arizona. Two of the arborescent cacti, senita and organpipe, together with two species of limberbush (Jatropha cardiophylla and J. cinerea) and elephant tree (Bursera microphylla, which occurs on hillsides near the transect plots) constitute the dominant members of the Central Gulf Coast phyto-geographic subdivision of the Sonoran Desert (Shreve 1951). The co-occurrence of these species in Senita Basin constitutes one of the northernmost associations of vegetation typical of the Sonoran Gulf Coast.

The cacti are one of the dominant groups occurring in Senita Basin, accounting for one half of the species in plot 4W1. In addition to the arborescent cactus species mentioned above, five species, barrel cactus (Ferocactus wislizeni), pincushion cactus (Mammillaria microcarpa), hedgehog cactus (Echinocereus engelmanni), jumping cholla (Opuntia fulgida), and staghorn cholla (O. acanthocarpa) are found in the study plots.

Rodents.--The rodent community in Senita Basin is composed of three species found in lower bajada situations, such as Growler Valley or Aguajita Spring. The relative importance of

the dominants, however, is different. Merriam's kangaroo rat (Dipodomys merriami) occurs in lower densities in Senita Basin than in typical lower bajada areas, and the desert pocket mouse (Perognathus penicillatus) occurs in higher densities than at any other study site in the monument. It appears that the desert pocket mouse has replaced Merriam's kangaroo rat as the dominant member of the rodent fauna in this locality because the soil of Senita Basin, mostly gravel derived from decomposed granite, is too coarse to provide optimum habitat for the kangaroo rat. It is likely that the white-throated woodrat (Neotoma albigula) is present in response to the higher plant cover in Senita Basin relative to other localities (Table 26).

Dos Lomitas Exclosure

Vegetation.—The same perennial plant species, desert saltbush (Atriplex polycarpa) and narrow-leaf saltbush (A. linearis), are dominant within both the exclosure and control plots at Dos Lomitas. Many of the less abundant species also occur in both plots, as shown in tables 27 and 28. However, there are several important differences between the two plots (Figs. 30, 31).

Density and cover of perennial plants within the exclosure were approximately twice that in the control plot (Figs. 32, 33). The total density of perennial plant species is significantly higher ($P < 0.05$) in the exclosure than in the control plot. To a large extent this higher density can be attributed to larger numbers of narrow-leaf saltbush which is approximately three times as dense in the exclosure as in the control plot, and to a lesser extent to desert saltbush which has a density approximately twenty percent higher within the exclosure. The other species shared by the two plots occur in approximately the same densities in both plots.

The occurrence of several species in the exclosure which are absent from the control plot also contributes to the higher plant density within the exclosure. For the most part these species

Table 26. Population data for rodents along Transect No. 4, Senita Basin. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectares. Relative abundance is calculated from density estimate figures. Trapping was carried out during November 1975 and June 1976.

Species	Plot 400			Plot 4W1			Plot 4W2		
	captures	density	rel. abund.	captures	density	rel. abund.	captures	density	rel. abund.
<u>Perognathus penicillatus</u>	16.4	21	0.84	24.2	18	0.69	21.4	26	0.87
<u>Dipodomys merriami</u>	2.1	2	0.08	6.8	8	0.31	0.8	1	0.03
<u>Neotoma albigula</u>	1.6	2	0.08	--	--	--	0.8	1	0.03
<u>Perognathus baileyi</u>	--	--	--	--	--	--	2.3	2	0.07
Total	20.1	25	1.00	31.0	26	1.00	25.3	30	1.00
Species diversity (H')	0.239			0.269			0.225		
Total trap nights	189			132			131		

Table 27. Perennial plant density and cover in the Dos Lomitas exclosure.

	Species	Density (no./0.1 ha)	Cover %
1.	<u>Atriplex linearis</u>	101.7	
2.	<u>Atriplex polycarpa</u>	89.7	7.51
3.	<u>Prosopis juliflora</u>	3.4	5.07
4.	<u>Lycium andersoni</u>	1.3	0.14
5.	<u>Opuntia leptocaulis</u>	1.5	
6.	<u>Ambrosia deltoidea</u>	1.2	0.06
7.	<u>LLycium parishii</u>	1.0	0.08
8.	<u>Mammillaria microcarpa</u>	1.0	
9.	<u>Opuntia acanthocarpa</u>	1.0	
10.	<u>Ditaxis neomexicana</u>	0.4	
11.	<u>Datura discolor</u>	0.4	
12.	<u>Echinocereus engelmanni</u>	0.4	
13.	<u>Cucurbita digitata</u>	0.3	
14.	<u>Aristolochia watsoni</u>	0.2	
15.	<u>Larrea divaricata</u>	0.2	
16.	<u>Opuntia spinosior</u>	0.2	
17.	<u>Cereus giganteus</u>	0.1	
18.	<u>Cercidium floridum</u>	0.1	
19.	<u>Condalia globosa</u>	0.1	
20.	<u>Nicotiana trigonophylla</u>	0.1	
21.	<u>Opuntia fulgida</u>	0.1	
22.	<u>Tumamoca macdougali</u>	0.1	
	Total	204.2	16.27
	Species diversity (H')	0.454	

Table 28. Perennial plant density and cover in the Dos Lomitas control plot.

	Species	Density (no./0.1 ha)	Cover (%)
1.	<u>Atriplex polycarpa</u>	73.7	3.41
2.	<u>Atriplex linearis</u>	34.7	0.22
3.	<u>Prosopis juliflora</u>	1.7	3.68
4.	<u>Lycium andersoni</u>	2.7	0.15
5.	<u>Opuntia leptocaulis</u>	1.3	0.01
6.	<u>Ambrosia deltoidea</u>	1.6	
7.	<u>Mammillaria microcarpa</u>	0.4	
8.	<u>Cereus giganteus</u>	0.3	
9.	<u>Larrea divaricata</u>	0.3	
10.	<u>Lycium parishii</u>	0.3	
11.	<u>Opuntia acanthocarpa</u>	0.3	
12.	<u>Cereus greggi</u>	0.1	
13.	<u>Condalia globosa</u>	0.1	
14.	<u>Opuntia fulgida</u>	0.1	
	Total	117.4	7.47
	Species diversity (H')	0.440	



Fig. 30. Dos Lomas enclosure, a view southward from the gate on the north fence. Shrubs are saltbush (Atriplex polycarpa and A. linearis). Tree in the right background is mesquite (Prosopis juliflora). Dead remains of annual plants are visible in the right center and left rear. Photographed 12 September 1975.

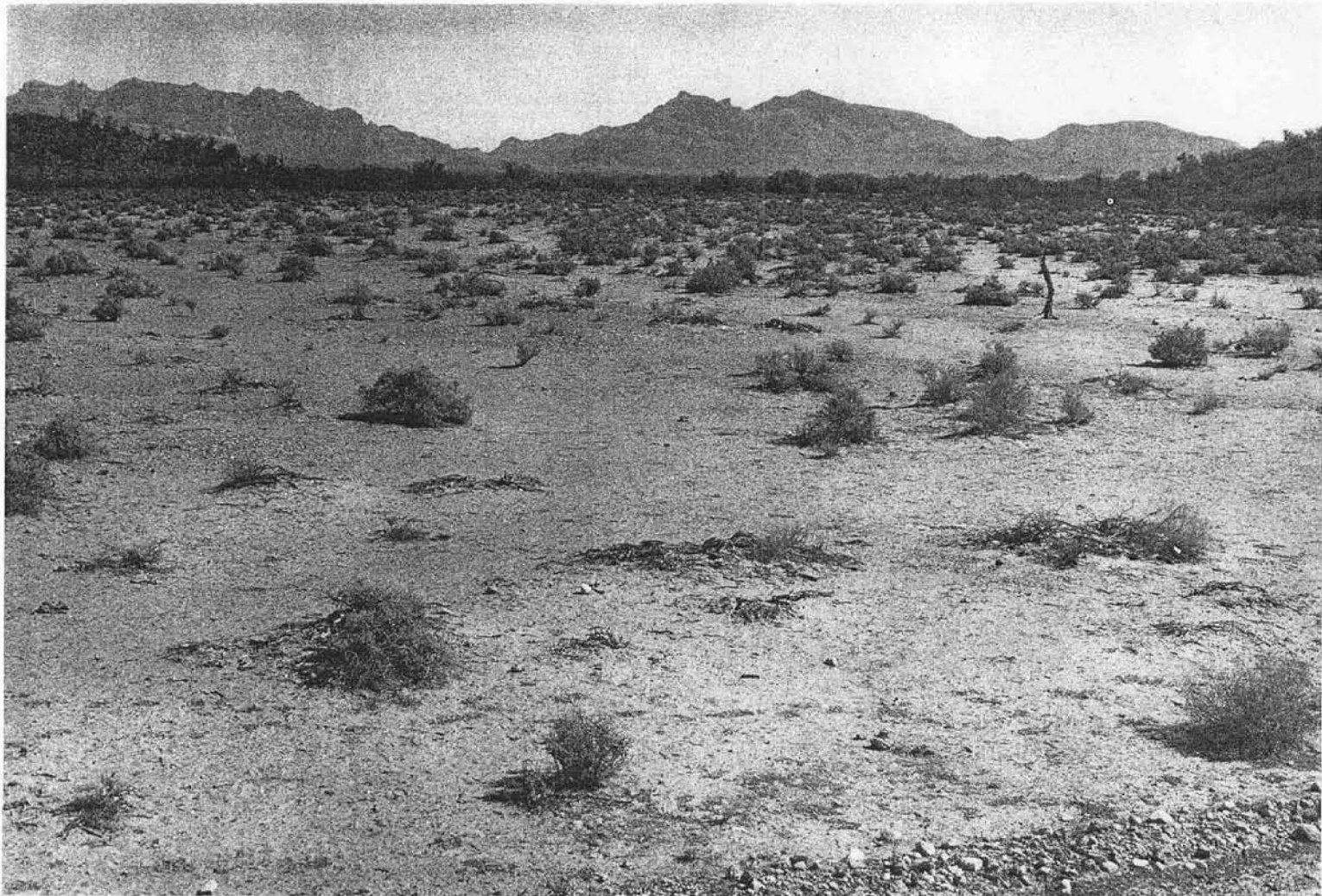


Fig. 31. Dos Lomitas control plot, a view north from the gate on the north enclosure fence. Shrubs are saltbush (*Atriplex polycarpa* and *A. linearis*). Compare the stunted appearance of the plants and the absence of dead ground cover with vegetation in Fig. 30. Photographed 12 September 1975.

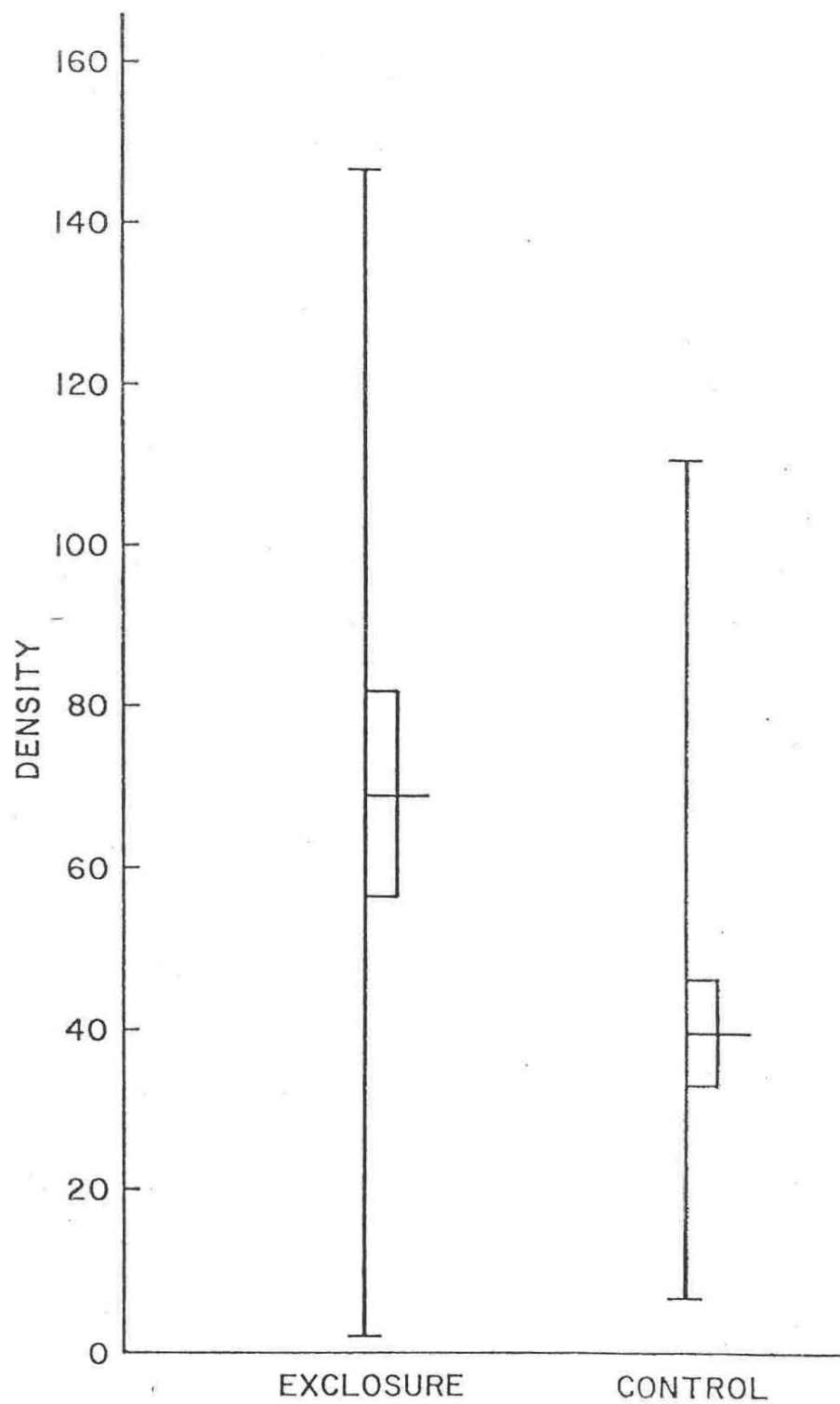


Fig. 32. Mean, range and 95% confidence interval of perennial plant density (no. of individuals per subplot) in the Dos Lomitas exclosure and control plots. Plant density outside the exclosure is depressed by livestock grazing. Statistics in Appendix III.

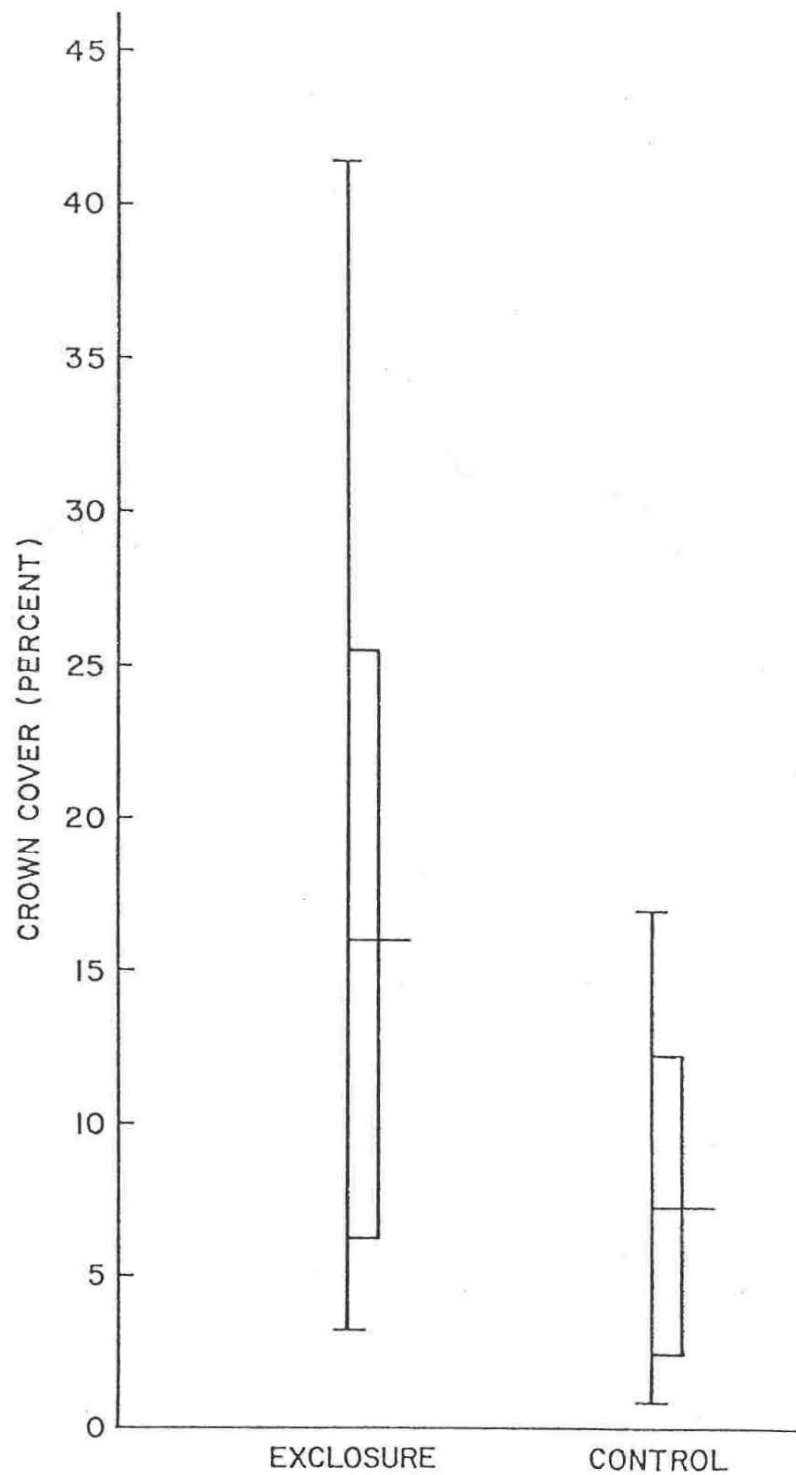


Fig. 33. Mean, range and 95% confidence interval of perennial plant cover in the Dos Lomitas exclosure and control plots. Lower cover outside the exclosure is a result of livestock grazing. Statistics in Appendix III.

are herbaceous root-perennials or suffrutescent subshrubs such as thorn-apple (Datura discolor), Ditaxis neomexicana, and desert tobacco (Nicotiana trigonophylla). Three root-perennial species found only in the protection of the exclosure are coyote-melon (Cucurbita digitata), Tumamoca macdougali, and Aristolochia watsoni, herbaceous vines which commonly grow only in the canopy of shrub species.

Perennial plant cover within the exclosure is also higher than in the control plot (Figs. 33, 34). The major differences again are found in the two dominant species. Narrow-leaf saltbush cover is 15 times greater within the exclosure than in the control plot and cover of desert saltbush is approximately twice that within the control plot. Other relatively abundant species such as mesquite (Prosopis juliflora) and wolfberry (Lycium andersoni) have similar cover values in both plots. The low saltbush cover outside the exclosure is a result of heavy browsing by livestock, as evidenced by the severely hedged condition and the almost complete absence of inflorescences and fruit on unprotected plants (Fig. 35). Damage from intense grazing pressure is also evidenced by deep gully erosion (Fig. 36).

Rodents and lagomorphs.--Greater density and cover of the plant community in the exclosure is reflected in differences in the small mammal population density and structure as shown in table 29. Merriam's kangaroo rat (Dipodomys merriami) and the desert pocket mouse (Perognathus penicillatus) are the dominant species in both plots. They occur with similar densities in both plots, being slightly more abundant inside the exclosure. The southern grasshopper mouse (Onychomys torridus), transient, occurs infrequently in both plots.

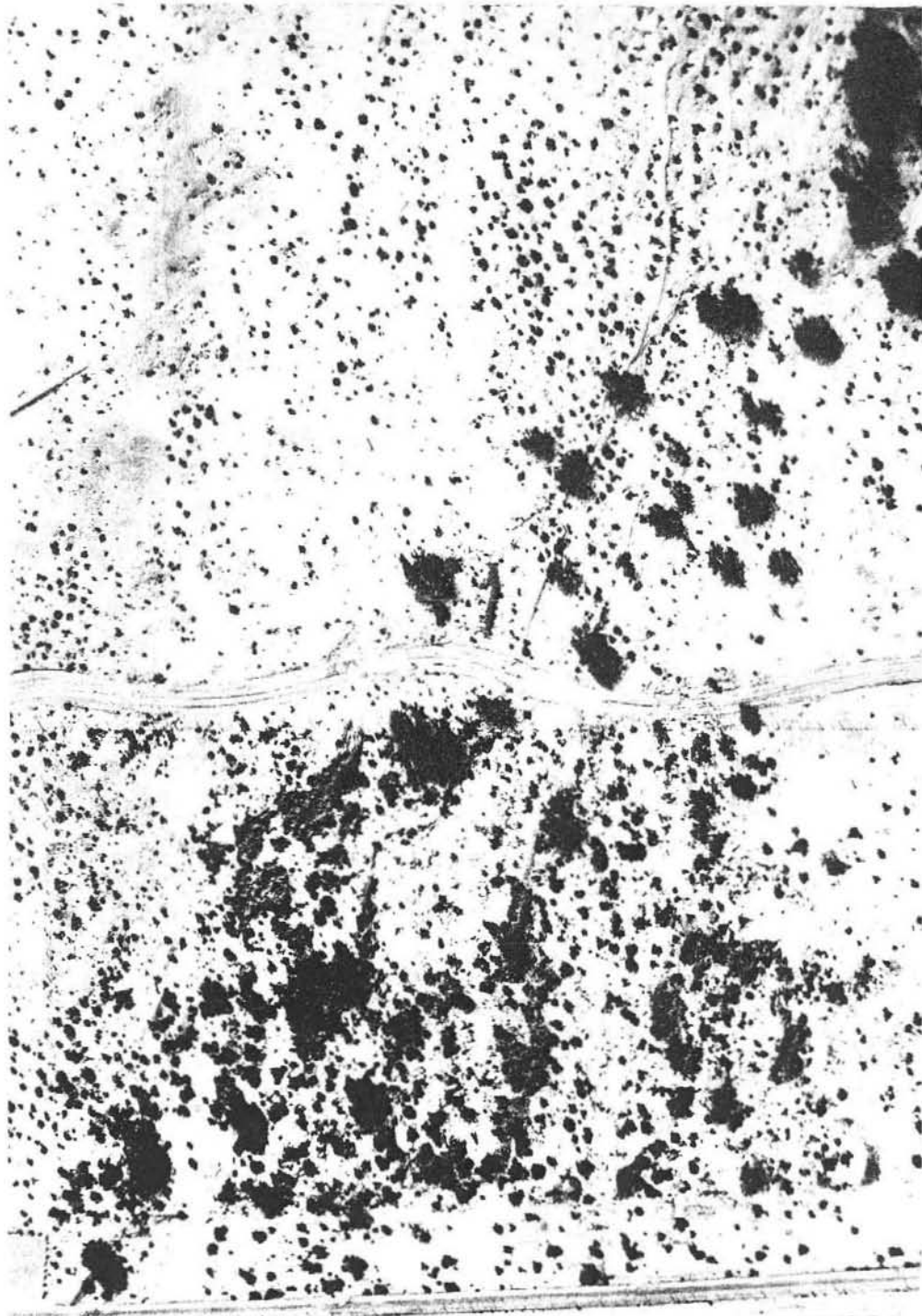


Fig. 34. Aerial photograph of the Dos Lomitas enclosure and control plots (exclosure on the bottom, see Fig. 7). Greater cover of perennial and dead annual plants is clearly visible inside the exclosure. Photographed November 1975.

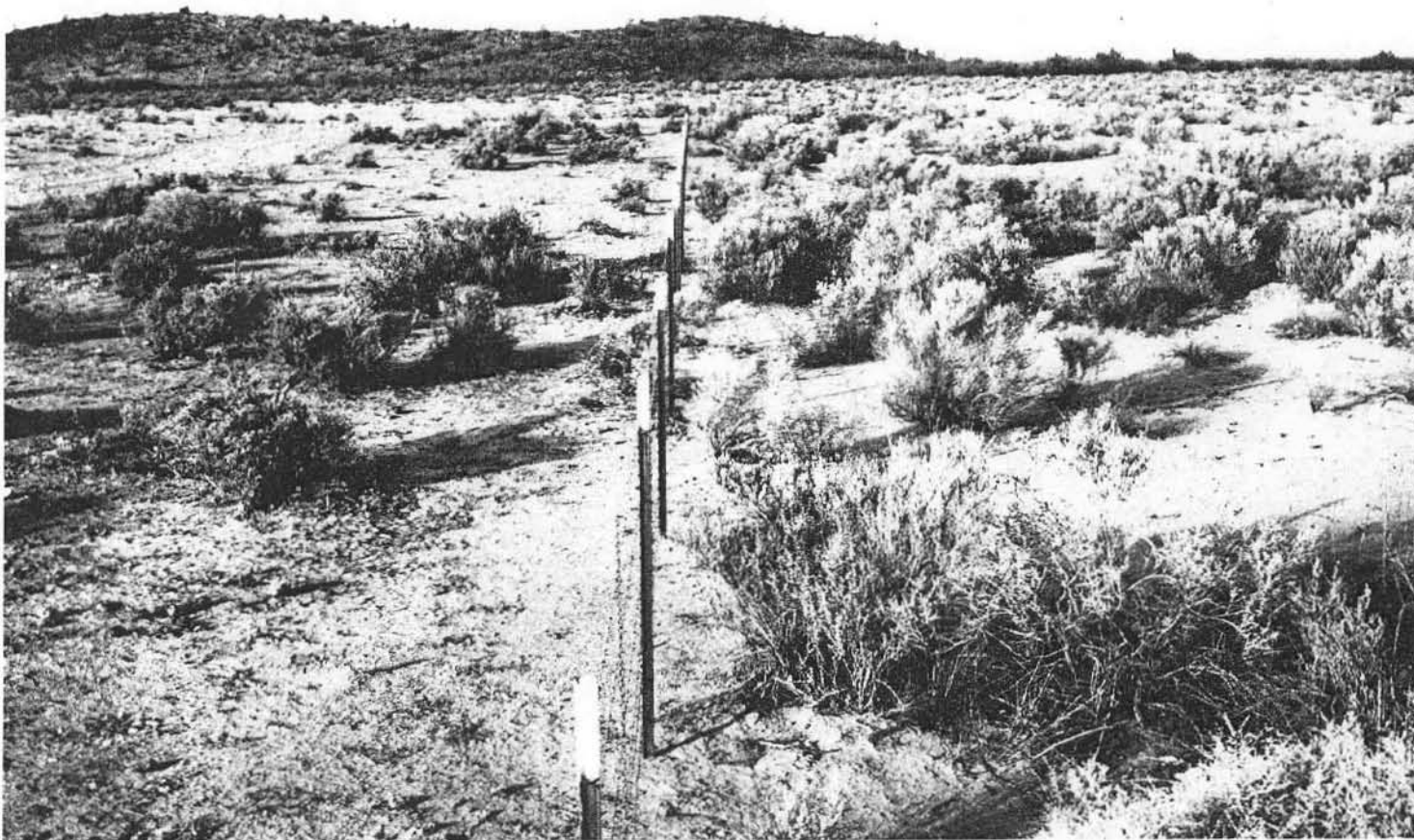


Fig. 35. View north along the west edge of the Dos Lomitas enclosure (on right) shows the effect of intensive livestock grazing on the reproductive status of saltbush (*Atriplex* sp.). Vigorous plants on the right, protected from grazing, bear abundant light-colored fruits. Fruits are absent from severely hedged unprotected plants on the left. Photographed 1 December 1975.



Fig. 36. Active gully erosion 200 meters east of the Dos Lomitas exclosure. Note the stunted saltbush (Atriplex sp.) in the background. Photographed 1 December 1975.

Table 29. Population data for small mammals in Dos Lomitas enclosure and control plots. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectares. Relative abundance is calculated from density estimate figures. Trapping was carried out during May 1975, September 1975, January 1976, and April 1976.

Species	Enclosure			Control		
	captures	density	rel. abun.	captures	density	rel. abun.
<u>Dipodomys merriami</u>	11.2	16	0.54	12.4	15	0.83
<u>Perognathus penicillatus</u>	4.7	5	0.17	1.7	2	0.11
<u>Onychomys torridus</u>	0.3	1	0.03	0.6	1	0.06
<u>Neotoma albigula</u>	1.4	3	0.10	--	--	--
<u>Peromyscus eremicus</u>	1.1	2	0.07	--	--	--
<u>Perognathus amplus</u>	0.6	1	0.03	--	--	--
<u>Perognathus baileyi</u>	0.3	1	0.03	--	--	--
<u>Sylvilagus auduboni</u>	*	1	0.03	--	--	--
Total	19.6	30	1.00	14.7	18	1.00
Species diversity (H')		0.639			0.246	
Total trap nights		354			358	

* Population estimated by visual census.

A major difference between the two plots is the higher total number of mammal species in the enclosure. Two species, the white-throated woodrat (Neotoma albigula) and the cactus mouse (Peromyscus eremicus), require relatively dense plant cover (Bradley and Mauer 1973). Moderate densities of these rodent species in the enclosure are attributed to greater vegetation cover and density (Figs. 37, 38). Similarly Bailey's pocket mouse (Perognathus baileyi) and the Arizona pocket mouse (Perognathus amplus) have a preference for foraging in shrubby rather than open microhabitats (Wondolleck 1975). Brush rabbits (Sylvilagus auduboni), although they occur in low densities in the enclosure, make a large contribution to the total biomass of the mammal community. The high density and biomass of small mammals found within the protection of the Dos Lomas enclosure strongly suggest that considerably larger populations of dependent carnivorous animals such as kit foxes (Vulpes macrotis), coyotes (Canis latrans), and raptorial birds would occur in the absence of livestock grazing pressure.

Armenta Well Enclosure

Vegetation. – The perennial plant community in the Armenta Well enclosure is the simplest, structurally and floristically, of those examined in Organ Pipe Cactus National Monument (Figs. 39, 40). With a single dominant species, creosotebush (Larrea divaricata), the Armenta Well site possesses the lowest perennial plant species diversity of any community sampled (Table 30).

Differences observed between perennial plant populations in the Armenta Well enclosure and the control plot, are shown in figures 41 and 42. Creosote occurs with similar densities and cover in both plots (Table 30). Two species, barrel cactus (Ferocactus wislizeni) and



Fig. 37. Mesquite (Prosopis juliflora) inside the Dos Lomitas enclosure. The accumulation of fallen branches beneath the tree canopy provides shelter for the white-throated woodrat (Neotoma albigula) and cactus mouse (Peromyscus eremicus). Photographed 1 December 1975.



Fig. 38. Mesquite (*Prosopis juliflora*) outside the Dos Lomitas exclosure (compare with Fig. 37). Accumulation of protective litter and growth of plants is retarded by browsing and shade-seeking livestock. Photographed 1 December 1975.



Fig. 39. Armenta Well enclosure from the gate on the east fence. Vegetation consists of a nearly pure stand of creosotebush (Larrea divaricata). Photographed 20 June 1976.

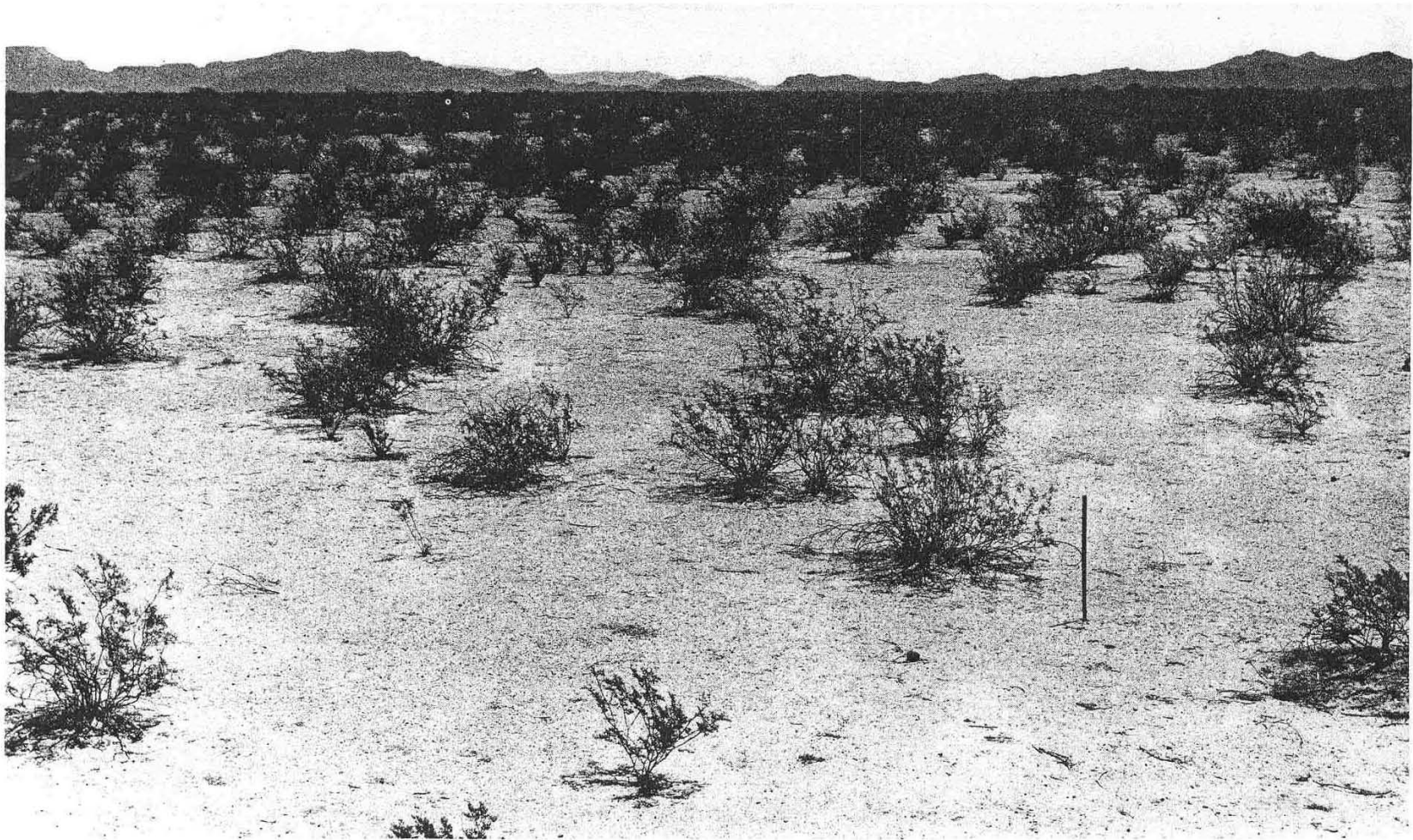


Fig. 40. Armenta Well control plot from the gate on the east fence of the exclosure. Vegetation is essentially the same as that within the exclosure (compare with Fig. 39). Photographed 20 June 1976.

Table 30. Perennial plant density, cover, and species diversity in. Armenta Well exclosure and control plots.

Species	<u>Density (no./0.1 ha)</u>		<u>Cover (%)</u>	
	exclosure	control	exclosure	control
<u>Larrea divaricata</u>	56.55	41.85	12.29	9.96
<u>Ferocactus wislizeni</u>	0.23	0.15		
<u>Holocanthus emoryi</u>	0.03	0.15		
<u>Mammillaria microcarpa</u>	0.03			
<u>Prosopis juliflora</u>	0.03			
<u>Lycium</u> sp.	0.03			
<u>Cucurbita digitata</u>	0.03			
Total	56.93	42.15	12.29	9.96
	Exclosure		Control	
Species diversity (H')	0.053		0.021	

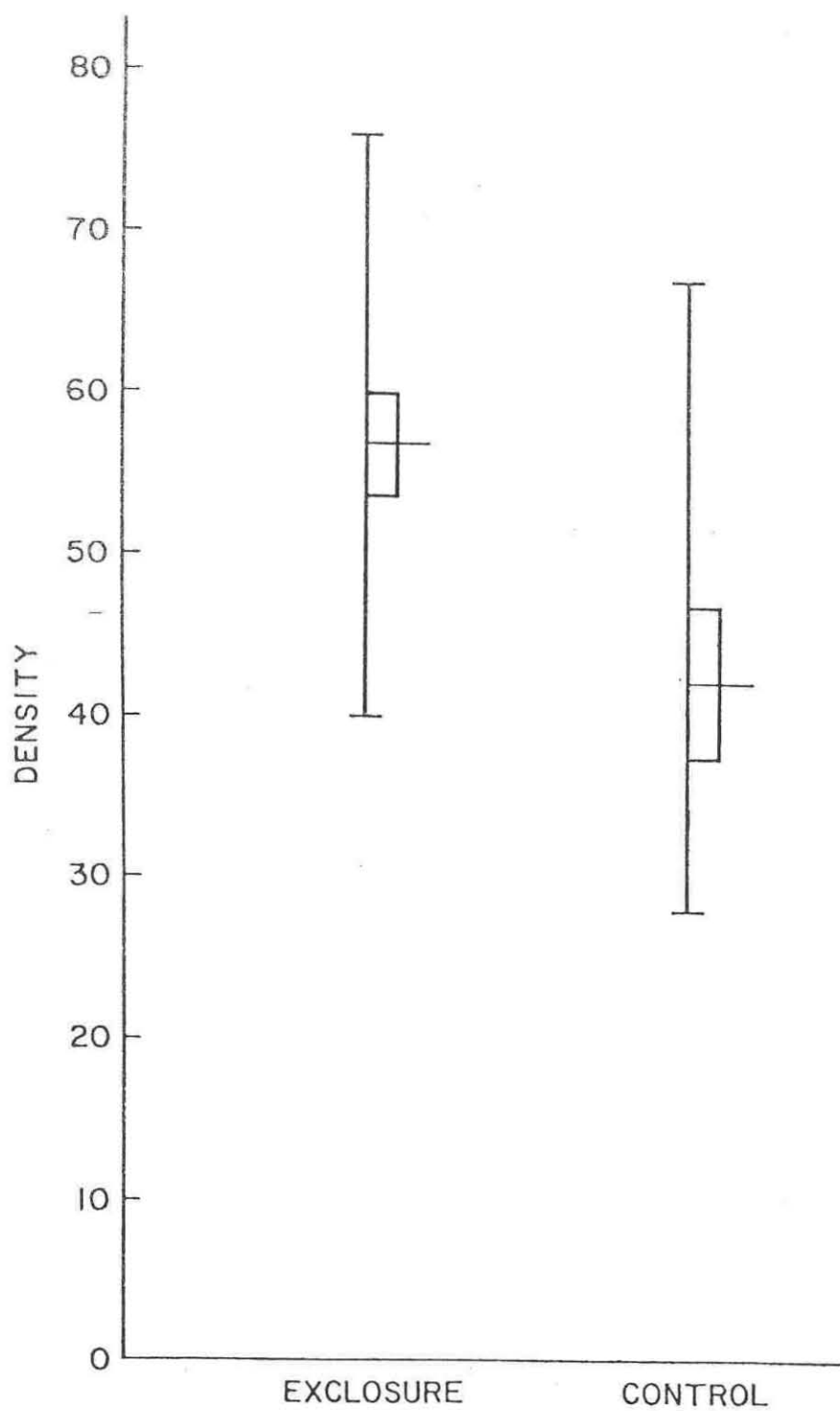


Fig. 41. Mean, range and 95% confidence interval of perennial plant density (no. of individuals per subplot) in the Armenta Well enclosure and control plots. Statistics in Appendix III.

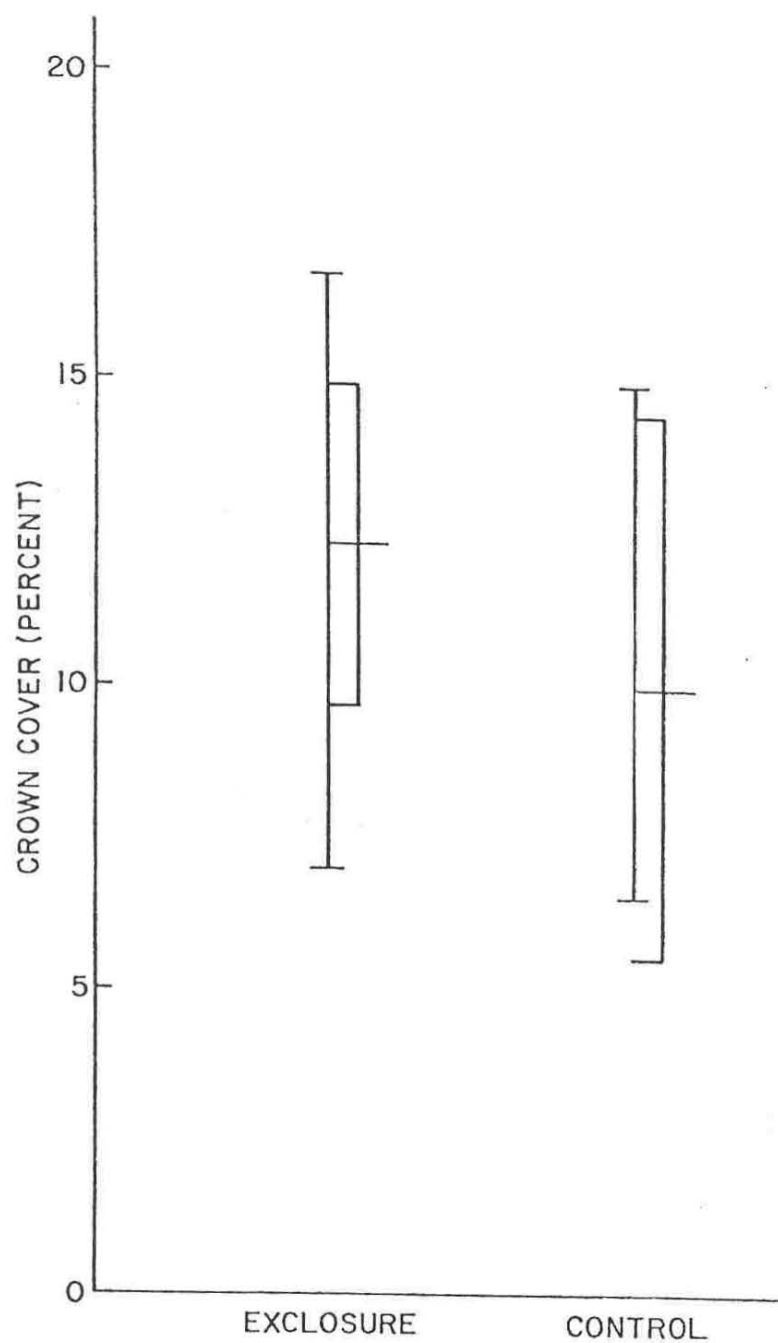


Fig. 42. Mean, range and 95% confidence interval of perennial plant cover in the Armenta Well enclosure and control plots. The means are not significantly different ($P > 0.05$). Statistics in Appendix III.

crucifixion-thorn (Holacantha emoryi), occur in both the exclosure and control plots. In addition, four species, pincushion cactus (Mammillaria microcarpa), mesquite (Prosopis juliflora), wolfberry (Lycium sp.), and coyote-melon (Cucurbita digitata), which occur in the exclosure are absent from the control plot. However, these minor species are present in such low densities (less than one individual per 0.1 ha) that they make no important contribution to the plant community.

It is not surprising that 12 years of protection from livestock grazing has resulted in no large differences between the perennial plant community in the Armenta Well exclosure and the adjacent control plot. Creosotebush, by far the most abundant plant at the site, is not palatable to livestock and does not suffer greatly from grazing damage. To a large extent the occurrence of other species in this habitat is limited by edaphic factors, such as the low water availability of fine-textured lower bajada soils (Yang and Lowe 1956). Perennial species that do sustain grazing damage occur in such low abundance that such damage is relatively minor when considering the community as a whole.

Although no notable differences exist in the perennial vegetation of the two plots, an abundance of dead annual plants was observed only in the exclosure. This difference is particularly apparent in aerial photographs of the site (Fig. 43). In the control plot, dead annuals were almost completely lacking, in contrast to the exclosure where shallow swales and runnels contain dense stands of dead annuals. In the absence of livestock activity, dead annual plants remain in place for many months as evidenced by their persistence within the Armenta Well exclosure throughout the course of this investigation. Standing dead annuals act to reduce rainwater run-off and inhibit erosion such as that presently occurring 150 meters south of the exclosure site (Figs. 44, 45).

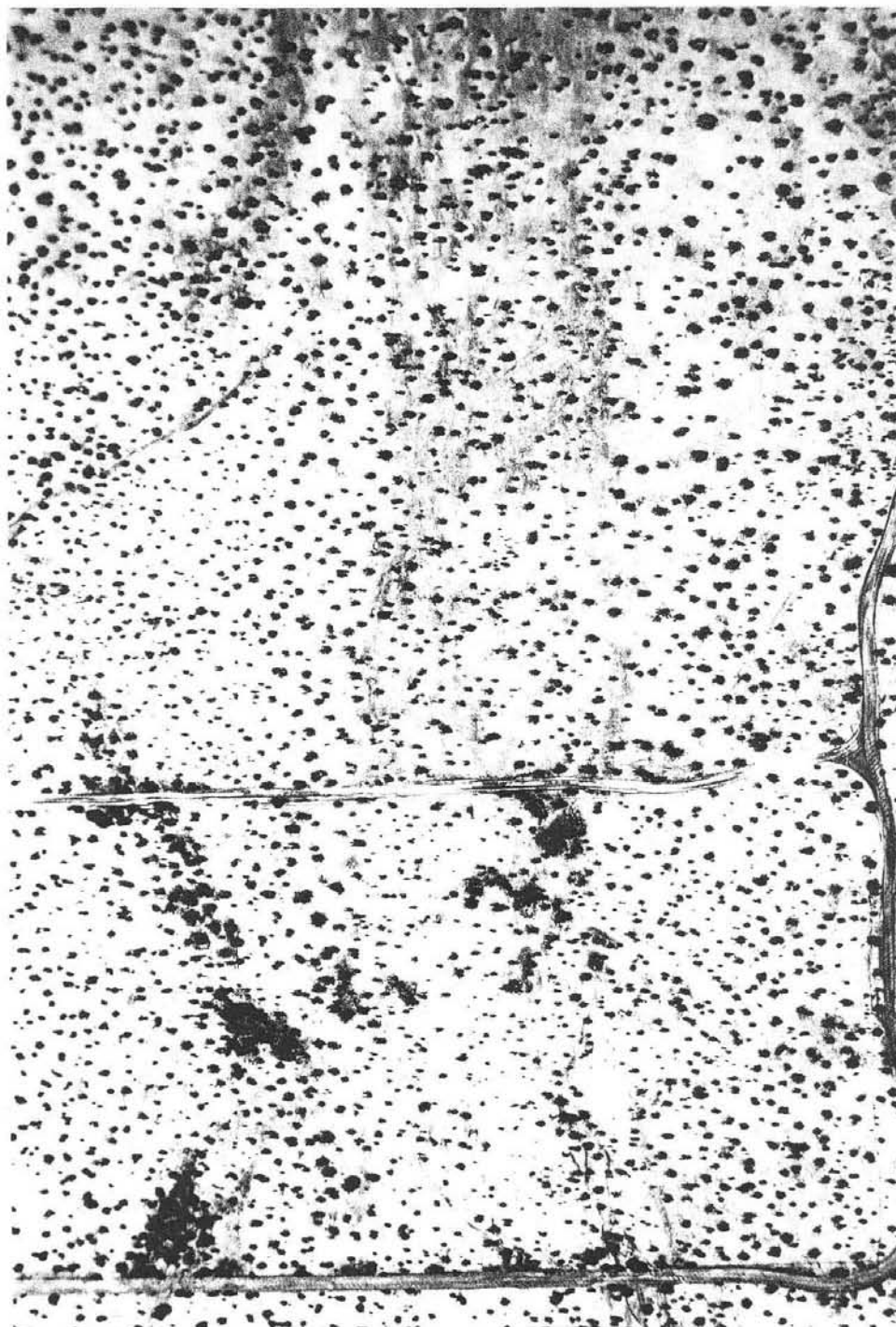


Fig. 43. Aerial view of the Armenta Well enclosure and control plots. The enclosure is at the bottom of the photograph (see Fig. 6). Dark patches in the enclosure, absent in the control plot, are swales with dead annual plants. Photographed November 1975.



Fig. 44. Active gully erosion 200 meters south of the Armenta Well enclosure. Channels are approximately 1.5 m deep. Photographed 29 January 1976.



Fig. 45. Head of channel cutting 150 meters south of the Armenta Well enclosure. The channels are approximately 0.9-1.2 m deep. Photographed 1 December 1975

Rodents.--Rodent populations in both the enclosure and control plots are essentially the same (Table 31). The most abundant species, Merriam's kangaroo rat (Dipodomys merriami) had estimated population densities higher than those in other sites such as Growler Valley, where it is also the dominant species. The large population estimates at this site may be due to migration activity which results in an excessive number of transient individuals and a consequent relative reduction in recapture of marked animals, as suggested by the results of O'Farrell (1974).

Both the rodent community and the plant community at Armenta Well are the least diverse of any sampled in the monument. Two minor members of the rodent community are the desert kangaroo rat (Dipodomys deserti) and the desert pocket mouse (Perognathus penicillatus) (Table 31). Armenta Well is the only site at which desert kangaroo rats were found. The occurrence of these animals, which characteristically occupy areas of sparse vegetation and fine-textured, loose soil, reflects the depauperate, open nature of the vegetation at this location. Desert pocket mice, although present, occur in low densities and it is likely that their numbers are limited by the lack of sufficient vegetation cover to provide suitable foraging habitats.

Aerial Photography Analysis

Estimates of total perennial plant cover and density obtained from analysis of aerial photographs were, with few exceptions, lower than estimates from ground measurements. General patterns of relative plant cover and abundance provided by photo analysis were closely comparable to those obtained from ground data.

Cover values obtained for perennial plants from largescale, color-infrared aerial photographs correspond closely with values obtained from on-the-ground measurements. For

Table 31. Population data for rodents in Armenta Well enclosure and control plots. Captures indicate number of individuals captured per 100 trap nights. Density is estimated number of individuals per 0.5 hectares. Relative abundance is calculated from density estimate figures. Trapping was carried out during June 1975, July 1975, February 1976, and April 1976.

Species	Enclosure			Control		
	captures	density	rel. abund.	captures	density	rel. abund.
<u>Dipodomys merriami</u>	14.8	71	0.97	13.5	68	0.93
<u>Dipodomys deserti</u>	1.6	2	0.03	1.9	3	0.04
<u>Perognathus penicillatus</u>	--	--	--	1.5	2	0.03
Total	16.4	73	1.00	16.9	73	1.00
Species diversity (H')	0.058			0.131		
Total trap nights	257			260		

14 of 20 plots examined, aerial photo analysis yielded cover values which fell within the 95% confidence interval of those obtained from ground measurements ([Table 32](#)).

Perennial plant density estimates derived from aerial photo analysis were consistently lower than the results obtained from ground measurements. Density estimates from the aerial photographs fell within the 95% confidence intervals of those obtained from ground measurements for only four of the 20 study plots (Table 32).

These results agree with those of Fish and Smith (1973) who found that aerial photo analysis detected crown cover differences between two desert shrub communities nearly as well as ground measurements. Their data also indicate that the efficiency of density estimates is reduced by inability to detect young individuals and to distinguish between individuals in a clump, factors which have a relatively small effect on cover estimates.

It is noteworthy that in this study all four of the aerial photo density estimates which closely agree with ground-level measurements were made on plots in the creosotebush-bursage community. This community is the simplest structurally of all those sampled, possessing very few subordinate species growing beneath the canopy of the community dominants. In all communities with multiple levels of trees, shrubs and suffrutescent plants, density estimates were below the 95% confidence limit determined from ground-level measurements.

Aerial photo analysis showed no large difference in density or cover between the enclosure and the control plots at Armenta Well. It did, however, show considerable differences in cover and density between the Dos Lomas enclosure and control plots. Both of these results are consistent with ground truth.

A serious limitation of aerial photo analysis is that it does not permit identification of subordinate members of the community. Driscoll and Coleman (1974) emphasize the difficulty

Table 32. Summary of perennial plant cover and density in 20 study plots estimated from ground data, and comparison with estimates from analysis of aerial photographs.

Plot	Species (no.)	<u>Cover %</u>		Density (no. /0.1 ha	
		Ground	Air	Ground	Air
100	7	10.87	7.98 ^{1/}	144	112 ^{1/}
1SE1	6	15.20	9.13	308	216
1SE2	5	7.55	8.60 ^{1/}	137	117 ^{1/}
1SE3	5	20.10	12.24	180	133 ^{1/}
200	5	3.43	3.81 ^{1/}	295	183
2E1	13	10.51	13.31 ^{1/}	299	198
2E2	10	16.64	10.42 ^{1/}	424	208
2E3	11	9.75	11.91 ^{1/}	312	207
300	19	26.64	5.44	3439	506
3S1	26	41.36	20.48	1576	311
3S2	20	25.51	13.40	244	148
3S3	15	22.46	17.34 ^{1/}	536	184
3S4	24	27.74	18.90 ^{1/}	629	265
400	21	32.76	27.85 ^{1/}	449	269
4W1	12	21.86	19.80 ^{1/}	560	312
4W2	19	28.24	26.22 ^{1/}	675	333
AWX	2	12.29	8.86	9.93	40.37
AWC	3	9.96	8.08 ^{1/}	42.15	41.07 ^{1/}
DLX	8	16.07	13.69 ^{1/}	04.20	98.57
DLC	7	7.47	6.75 ^{1/}	117.40	78.15

^{1/} Estimated values fall within the 95% confidence interval of ground measurement data.

of identifying low-growing shrubs, particularly in mixed stands. In many cases relatively minor members of the community are the most severely affected by grazing. However, such damage could not be assessed from aerial photographs in the present study.

General Patterns of Diversity and Abundance

Regression analysis of the combined results from all the study plots in the monument, reveals patterns of perennial plant species diversity that are closely correlated with structural characteristics of the plant community. These patterns of increased diversity are generally related to an elevational gradient from the lower bajada, creosotebush-bursage community to the more complex upper bajada, paloverdesaguaro community (Yang 1957).

The close correlation of perennial plant species diversity with plant cover (Fig. 46) is attributed primarily to two factors, one environmental and one biotic. The soils of the upper bajada are generally coarser in texture than those of the lower bajada (Appendix V, VI) allowing greater rainwater infiltration rates and higher water availability to plants (Kramer 1969, Yang and Lowe 1956). The generally higher plantavailable soil moisture on the upper bajada allows more luxuriant plant growth, producing greater density and cover, and allows the survival of species with higher minimum water availability tolerances.

Secondly, these diversity-structure relationships are attributed to dependent biotic associations. It is likely that the presence of high species diversity at sites of high plant cover reflects the dependence of less robust species upon more dominant members of the community. Several weakly perennial suffrutescent members of the comparatively complex paloverde-saguaro community are found, almost without exception, only under the protective canopy of larger plants. The occurrence of such species, although ultimately controlled by environmental

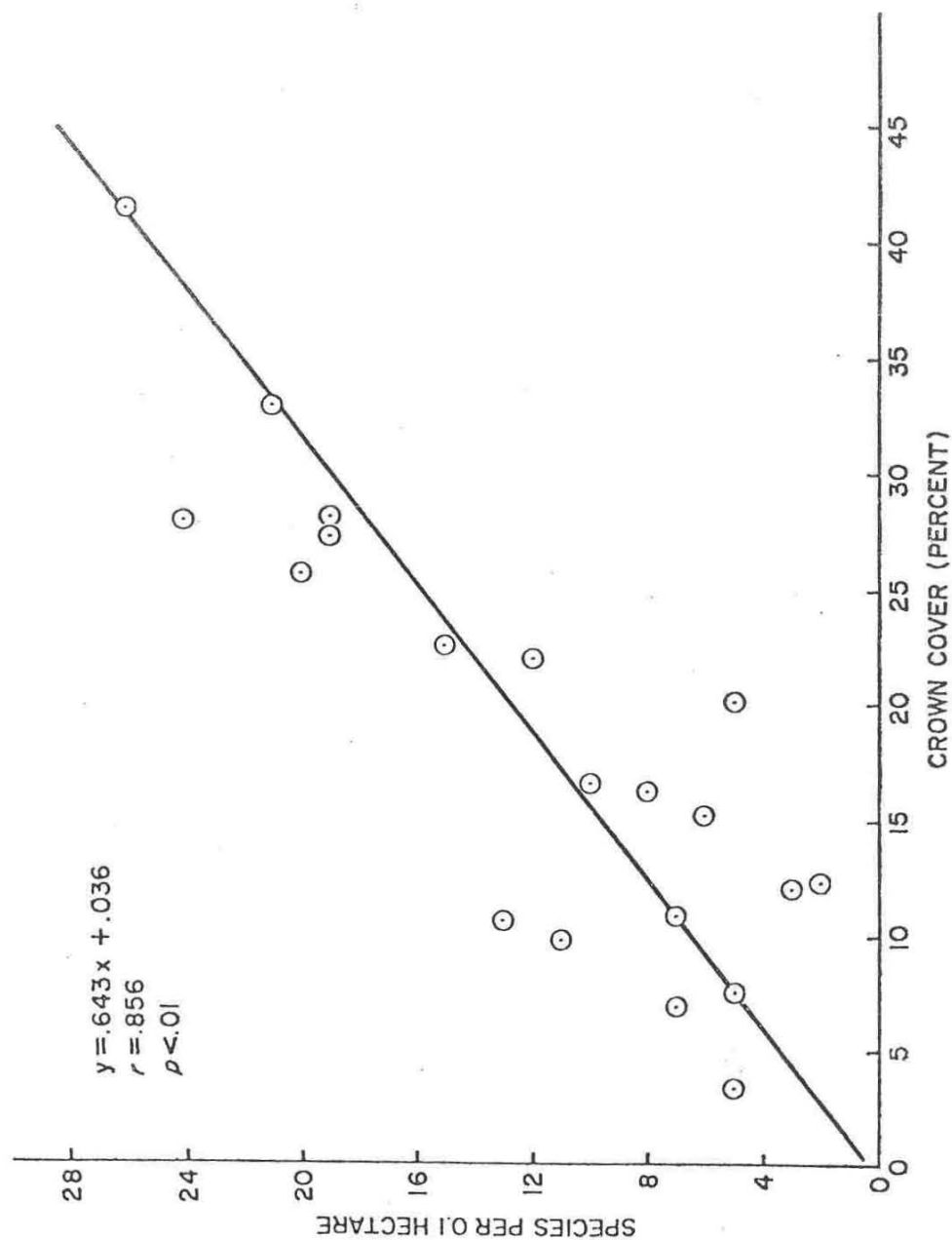


Fig. 46. Relationship between perennial plant species diversity and cover in 20 plots at Organ Pipe Cactus National Monument. Upper bajada sites tend to fall in the upper right part of the graph and lower bajada sites in the lower left. Coverage data in Table 32.

conditions, may be dependent to a great extent upon the presence of suitable protective associates.

SUMMARY AND CONCLUSIONS

Ecological investigations on natural communities at Organ Pipe Cactus National Monument were conducted to evaluate the status of the principal biotic communities, and to establish data baselines for quantitative evaluation of future ecological changes and determination of rates of natural regeneration of degraded biotic communities.

Transects employing a series of permanent study plots established in each of the four principal biotic communities were used to describe and evaluate the status of plant communities and rodent populations. Additional data on two communities were obtained from pre-existing exclosures and paired adjacent control plots. Supplemental data were obtained by aerial and ground photography. Data from transects and paired exclosure-control plots were used to evaluate differential impacts of livestock grazing.

Biotic communities.--Important differences in structure and composition exist between each of the four plant communities sampled. In order of increasing complexity, these are the creosotebush-bur-sage, saltbush, Bursera-Jatropha, and paloverde-saguaro communities. Within each community, large variations in structure and composition result from topographic and edaphic differences, as well as from differences in livestock grazing pressure.

Patterns of perennial plant species diversity are closely correlated with structural characteristics of the plant community. Species diversity increases with plant density and cover. With increasing complexity of the physical structure of the plant community, additional dependent species occur beneath the protective canopy of larger trees and shrubs.

Distribution and abundance of rodents are related to both soil and plant community characteristics. Generally, rodent species diversity and abundance increase with the complexity

of the plant community as characterized by increased species diversity, crown cover, and stratification. Some rodent species associated primarily with fine-textured soils are rare or absent in habitats with rocky soils. Other species are associated primarily or exclusively with rocky or coarse-textured soils.

Baseline data.--Transect studies as employed in this investigation provide information on the relative impact of grazing on existing biotic communities. These are communities that are already severely degraded by a long history of abuse from overgrazing. Transect data do not provide direct information on the historic condition of these communities, nor do they reveal the full extent to which these communities have been altered by continued grazing abuse.

Livestock exclosures allow comparison of grazed and protected communities, providing information on the net impact of livestock grazing since exclosures were installed. Unfortunately, conditions within exclosure plots and paired control plots examined in this study were not documented at the time exclosures were installed. Thus, while comparison of the data from exclosure and control plots clearly indicates the relative impacts of livestock grazing upon the two communities examined, the observed differences between grazed and protected plots do not necessarily constitute a measure of actual rates of natural regeneration following release from livestock grazing pressure. Specific recovery rates will be established by periodic followup studies providing data for comparison with baseline data obtained during this establishment phase of the investigation.

Large-scale color-infrared aerial photography is a useful tool for documenting and evaluating the status of the principal plant communities occurring within the monument. Identification of primary species, and estimates of perennial total plant density and total cover can be accomplished by analysis of such photographs. Aerial photographs provide lower

estimates of density and cover than ground measurements. The accuracy of such estimates decreases with increased complexity and stratification of the plant community. The method is not effective for obtaining information on seedlings, small plants, or subordinate plants.

It must be emphasized that this is manifestly a long-range project. The ultimate value of the data reported here lies in their future utility, providing a qualitative and quantitative baseline on natural community status for subsequent comparative evaluations. Using the techniques employed in this investigation, future studies will further reveal basic natural relationships, and provide essential information on the nature and trend of changes in these important biotic resources.

Livestock grazing.--Intensive grazing by livestock selectively removes palatable species from the plant community resulting in lower density and cover if not the complete elimination of some preferred plant species.

Grazing-caused degradation of the plant community indirectly reduces rodent numbers and species diversity by reducing or eliminating essential foraging habitat for some species. The overall impact of intensive grazing is greatest in simple communities dominated by or containing a relatively high proportion of palatable species. In the three intensively grazed biotic communities examined during this investigation, the greatest observed impact from livestock grazing was in the saltbush community, a relatively simple community dominated by highly palatable shrub species. The least damage was observed in the creosotebush-bur-sage community, a simple community dominated by unpalatable creosotebush. Damage to the more complex paloverde-saguaro community was intermediate between that observed in the two simpler communities. Grazing impact on the Bursera-Jatropha community was not evaluated.

Large differences in grazing intensity and damage vegetation occur within 1/2 mile of livestock watering with severe damage occurring in the immediate vicinity sources. Evidence of intensive grazing was observed in study plots located within a range of 1/2 to 3-4 miles from watering to sites, of water sites. Within this distance range, however, the data were not sufficient to reveal definitive gradients of decreasing livestock grazing pressure with increasing distance from water sources. Differences in plant community structure and composition resulting from differential livestock grazing pressure were in some instances obscured by large plot-to-plot variations attributable to topographic and edaphic factors.

Ongoing extensive accelerated soil erosion is directly attributable to intensive livestock grazing. Trampling and removal of annual and perennial vegetation increases water run off, loss of soil, and hastens the breakdown and loss of organic materials. In intensively grazed areas with fine-textured soils, erosion of some sites has progressed to the point where impacts on the associated biotic communities are largely irreversible.

In summary, livestock grazing has upon the natural biotic communities of Organ Pipe Cactus National Monument. Consumptive use by livestock has far exceeded the natural had a devastating effect excessive numbers of productivity of the environment. Existing biotic communities are artifacts of the original natural communities grossly altered in structure and species composition by the pressure of long continued intensive livestock grazing pressure. Further degradation of these communities is occurring under continuing livestock grazing pressure. If the intended purposes of the monument are to be fulfilled, it is imperative that domestic livestock grazing be discontinued at the earliest possible date.

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APPENDIX I

Location of permanent 0.1 hectare study plots in Organ Pipe Cactus National Monument

Plot No.	Location
100	0.25 mi. west of Cabeza Prieta-Bates Well Rd. junction, 10 meters north of road.
1SE1	0.4 mi. south of Cabeza Prieta-Bates Well Rd. junction, 10 meters west of road.
1SE2	0.4 mi. south of Cabeza Prieta-Bates Well Rd. junction, 10 meters west of road.
1SE3	2.4 mi. south of Cabeza Prieta-Bates Well Rd. junction, 10 meters west of road.
200	0.05 mi. east of Aguajita Spring turnoff, 10 meters north of Puerto Blanco Drive.
2E1	0.75 mi. east of Aguajita Spring turnoff, 30 meters east of USCGS benchmark A308-1952, 10 meters north of road.
2E2	1.85 mi. east of Aguajita Spring turnoff, 10 meters north of road, opposite USCGS benchmark B308-1952.
2E3	2.85 mi. east of Aguajita Spring turnoff, 10 meters north of road, next to USCGS benchmark C308-1952.
300	3.1 mi. east of Highway 85 on Alamo Canyon Rd., 10 meters north of road.

APPENDIX I

(Cont.)

Plot No.	Location
3S1	South of Alamo Canyon Campground heading 160 ⁰ to top of saddle, south of saddle heading 170 ⁰ 1/2 mi., 50 meters west of ridge
3S2	9.0 mi.along Ajo Mountain Drive from Highway 85, 10 meters west of road.
3S3	1.9 mi.along Ajo Mountain Drive from plot 3S2, 10 meters north of road.
3S4	1.3 mi.along Ajo Mountain Drive from plot 3S3, 10 meters west of road.
400	0.3 mi.west of the end of Senita Basin Rd., 10 meters north of road.
4W1	0.2 mi.west of plot 400 along Senita Basin Road, 10 meters north of road.
4W2	0.75 mi.west of plot 4W1 along Senita Basin Road, 10 meters west of road.

APPENDIX II

Perennial plant families and species in the study plots

	Family	Species	Common name
1.	Acanthaceae	<u>Siphonoglossa longiflora</u>	
2.	Aristolochiaceae	<u>Aristolochia watsoni</u>	indian-root
3.	Buxaceae	<u>Simmondsia chinensis</u>	jojoba
4.	Cactaceae	<u>Cereus giganteus</u>	saguaro
		<u>Cereus greggi</u>	night-blooming cereus
		<u>Cereus schottii</u>	senita cactus
		<u>Cereus thurberi</u>	organpipe cactus
		<u>Echinocereus engelmanni</u>	hedgehog cactus
		<u>Ferocactus wislizeni</u>	barrel cactus
		<u>Mammillaria microcarpa</u>	pincushion cactus
		<u>Opuntia acanthocarpa</u>	buckhorn cholla
		<u>Opuntia fulgida</u>	jumping cholla
		<u>Opuntia leptocaulis</u>	Christmas cactus
		<u>Opuntia phaeacantha</u>	prickly pear cactus
		<u>Opuntia spinosior</u>	cane cholla
		<u>Opuntia stanlyi</u>	devil cholla
5.	Chenopodiaceae	<u>Atriplex linearis</u>	saltbush
		<u>Atriplex polycarpa</u>	saltbush
		<u>Suaeda torreyana</u>	seep-weed
6.	Compositae	<u>Ambrosia ambrosioides</u>	canyon ragweed
	(Asteraceae)	<u>Ambrosia deltoidea</u>	triangle bur-sage
		<u>Ambrosia dumosa</u>	white bur-sage
		<u>Encelia farinosa</u>	brittlebush
		<u>Psilostrophe cooperi</u>	paperflower

APPENDIX II

(Cont.)

	Family	Species	Common name
7.	Cucurbitaceae	<u>Cucurbita digitata</u>	coyote-melon
		<u>Tumamoca macdougali</u>	
8.	Cruciferae (Brassicaceae)	<u>Lyrocarpa coulteri</u>	lyre pod
9.	Euphorbiaceae	<u>Ditaxis lanceolata</u>	
		<u>Ditaxis neomexicana</u>	
		<u>Euphorbia albomarginata</u>	spurge
		<u>Jatropha cardiophylla</u>	limberbush
		<u>Jatropha cinerea</u>	limberbush
		<u>Sapium biloculare</u>	yerba de fleche
10.	Fouquieriaceae	<u>Fouquieria splendens</u>	ocotillo
11.	Gramineae	<u>Hilaria mutica</u>	tobosa
		<u>Bouteloua</u> sp.	grama grass
12.	Labiatae	<u>Hyptis emoryi</u>	desert lavender
13.	Leguminosae	<u>Acacia constricta</u>	white-thorn
		<u>Acacia greggi</u>	catclaw acacia
		<u>Calliandra eriophylla</u>	false-mesquite
		<u>Cercidium floridum</u>	blue paloverde
		<u>Cercidium microphyllum</u>	foothill paloverde
		<u>Cassia covesi</u>	senna
		<u>Coursetia glandulosa</u>	
		<u>Dalea</u> sp.	indigo bush
		<u>Krameria grayi</u>	white ratany

APPENDIX II

(Cont.)

	Family	Species	Common name
13.	Leguminosae	<u>Olneya tesota</u>	ironwood
	(cont.)		
		<u>Prosopis juliflora</u>	mesquite
14.	Malpighiaceae	<u>Janusia gracilis</u>	
15.	Malvaceae	<u>Abutilon</u> sp.	mallow
		<u>Hibiscus coulteri</u>	rose-mallow
16.	Nyctaginaceae	<u>Allionia incarnata</u>	trailing-four-o'clock
17.	Rhamnaceae	<u>Condalia globosa</u>	gray-thorn
18.	Simaroubaceae	<u>Holacantha emoryi</u>	crucifixion thorn
19.	Solanaceae	<u>Datura discolor</u>	thorn-apple
		<u>Lycium andersoni</u>	wolfberry
		<u>Lycium parishii</u>	wolfberry
		<u>Lycium</u> sp.	wolfberry
		<u>Nicotiana trigonophylla</u>	desert tobacco
20.	Sterculiaceae	<u>Ayenia pusilla</u>	
21.	Zygophyllaceae	<u>Larrea divaricata</u>	creosotebush

APPENDIX III

Statistics for total density (number per 100 m²) and cover (percent) of perennial plants in 20 study plots at Organ Pipe Cactus National Monument.

Plot	Measurement	N	Mean (t SE)		Range
100	density	10	14.40 ±	2.25	4 - 24
	cover	11	10.87 ±	3.00	0.00 - 34.00
1 SE 1	density	10	30.80 ±	4.25	13 - 54
	cover	11	17.59 ±	2.17	4.50 - 27.00
ISE 2	density	10	13.70 ±	1.31	9 - 21
	cover	11	7.55 ±	1.78	0.00 - 18.00
1 SE 3	density	10	18.00 ±	2.85	4 - 44
	cover	11	20.09 ±	2.92	0.00 - 34.25
2.00	density	10	29.50 ±	2.56	17 - 44
	cover	11	3.43 ±	0.97	0.00 - 11.50
2 E 1	density	10	30.10 ±	2.83	19 - 46
	cover	11	10.51 ±	1.89	3.75 - 26.00
2 E 2	density	10	42.40 ±	7.40	15 - 71
	cover	11	16.64 ±	3.87	0.75 - 41.75
2 E 3	density	10	31.20 ±	3.42	19 - 48
	cover	11	9.75 ±	1.91	3.00 - 22.50
300	density	10	343.90 ±	24.7 3	195 - 434
	cover	11	26.63 ±	4.36	8.50 - 48.75
	Density ^{1/}	10	321.70 ±	28.6 1	190 - 420
	cover ^{1/}	11	11.79 ±	1.64	1.50 - 21.5

APPENDIX III

(Cont.)

Plot	Measurement	N	Mean (t SE)	Range
3S1	density	10	157.6 ± 17.98	42 - 226
	cover	11	41.52 ± 5.48	7.25 - 69.75
	density ^{1/}	10	14.60 ± 5.69	0 - 47
	cover ^{1/}	11	2.32 ± 1.47	0.00 - 15.75
3S2	density	10	24.40 ± 2.66	12 - 38
	cover	11	25.54 ± 3.00	9.00 - 39.75
	density ^{1/}	10	0.01 --	0 - 1
	cover ^{1/}	11	0.00 --	-- --
3S3	density	10	53.60 ± 6.64	31 - 89
	cover	11	22.39 ± 5.15	1.75 - 44.75
	density ^{1/}	10	18.50 ± 6.09	0 - 57
	cover ^{1/}	11	3.23 ± 1.25	0.00 - 12.50
3S4	density	10	62.90 ± 5.41	42 - 105
	cover	11	27.68 ± 4.97	8.25 - 60.75
	density ^{1/}	10	2.20 ± 1.99	0 - 20
	cover	11	1.14 ± 0.62	0.00 - 6.75
400	density	10	56.00 ± 8.19	12 - 93
	cover	11	32.68 ± 2.59	18.50 - 45.00
4W1	density	10	44.90 ± 4.32	18 - 60
	cover	11	21.86 ± 2.22	11.25 - 34.75
4W2	density	10	66.50 ± 7.43	31 - 113
	cover	11	28.50 ± 4.41	6.25 - 54.75

APPENDIX III

(Cont.)

Plot	Measurement	N	Mean ($\pm$ SE)		Range
AWX	Density ^{2/}	40	56.90 +	1.562	40 - 76
	cover	9	12.29 $\pm$	0.98	7.04 - 16.72
AWC	density ^{2/}	20	42.15 $\pm$	2.184	28 - 67
	cover	5	9.96 $\pm$	1.61	6.06 - 14.84
DLX	density ^{2/}	40	69.40 $\pm$	6.53	2 - 147
	cover	9	16.07 +	4.16	3.27 - 41.14
DLC	density ^{2/}	40	40.05 $\pm$	3.52	7 - 111
	cover	9	7.47 $\pm$	2.17	0.92 - 17.12

1/ Triangle bur-sage (Ambrosia deltoidea) only.

2/ No. of individuals per sub-plot.

APPENDIX IV

Precipitation at four study sites, Organ Pipe Cactus National Monument, May 1975-April 1976.

Location	May-July	Aug.-Oct.	Nov.-Jan.	Feb.-Apr.
Alamo Canyon	1.30	3.03	1.82	0
Dowling Well	0.78	0	0.22	1.39
Dos Lomitas	--	0.27	1.20	0.97
Armenta Well	--	1.55	1.06	1.27
Mean	0.52	1.21	1.08	0.91
26-year Mean 1944-1970 ^{1/}				9.17

^{1/} Monument headquarters, Sellers and Hill 1972.

APPENDIX V

Soil water content determined as percent dry weight in the top meter of soil at each study plot in Organ Pipe Cactus National Monument, early June 1975. Missing values indicate caliche which prevented sampling to a greater depth.

Plot	Depth of Sample (cm)									
	0	10	20	30	40	50	60	70	80	100
100	0.89	1.75	2.59	3.88	4.59	5.28	5.42	5.73	5.51	5.64
1SE1	0.75	2.34	4.06	5.22	5.87	5.87	6.31	7.22	7.86	7.57
1SE2	1.12	2.83	3.85	4.30	4.14	4.77	4.66	5.67	5.92	5.65
1SE3	1.28	3.34	3.93	3.91	3.97	4.28	3.99	3.95	3.81	3.97
200	0.61	2.61	8.06	3.73	3.87	3.05	3.09	3.17	2.49	2.35
2E1	0.39	1.98	3.36	3.49	2.94	2.34	3.02	3.62	2.83	3.26
2E2	0.98	2.75	3.86	4.17	4.56	5.15	5.26	4.98	6.13	6.54
2E3	1.10	4.34	5.92	6.50	7.03	6.48	8.31	7.33	7.62	7.59
300	2.28	3.93	8.23	10.15	8.46	10.27	--	--	--	--
3S1	1.29	3.77	7.27	7.98	7.16	8.34	11.09	9.97	--	--
3S2	1.64	3.22	4.42	6.31	6.86	7.01	--	--	--	--
3S3	2.08	0.97	2.54	8.65	6.77	2.44	5.66	7.59	--	--
3s4	7.62	8.69	5.72	2.20	20.08	8.66	4.95	1.73	5.56	6.00
400	1.84	0.74	2.13	1.98	0.87	0.93	1.14	1.93	1.97	1.88
4w1	1.81	1.91	2.17	2.20	2.35	2.72	2.38	2.19	2.24	2.17
4w2	1.89	2.28	2.35	2.60	2.40	2.50	2.40	2.04	2.63	2.46
AWX	1.30	4.34	6.28	4.89	4.24	4.18	3.69	2.52	4.16	1.95
DLX	1.59	4.34	5.83	3.29	2.79	2.74	2.73	2.50	2.53	2.90

APPENDIX VI

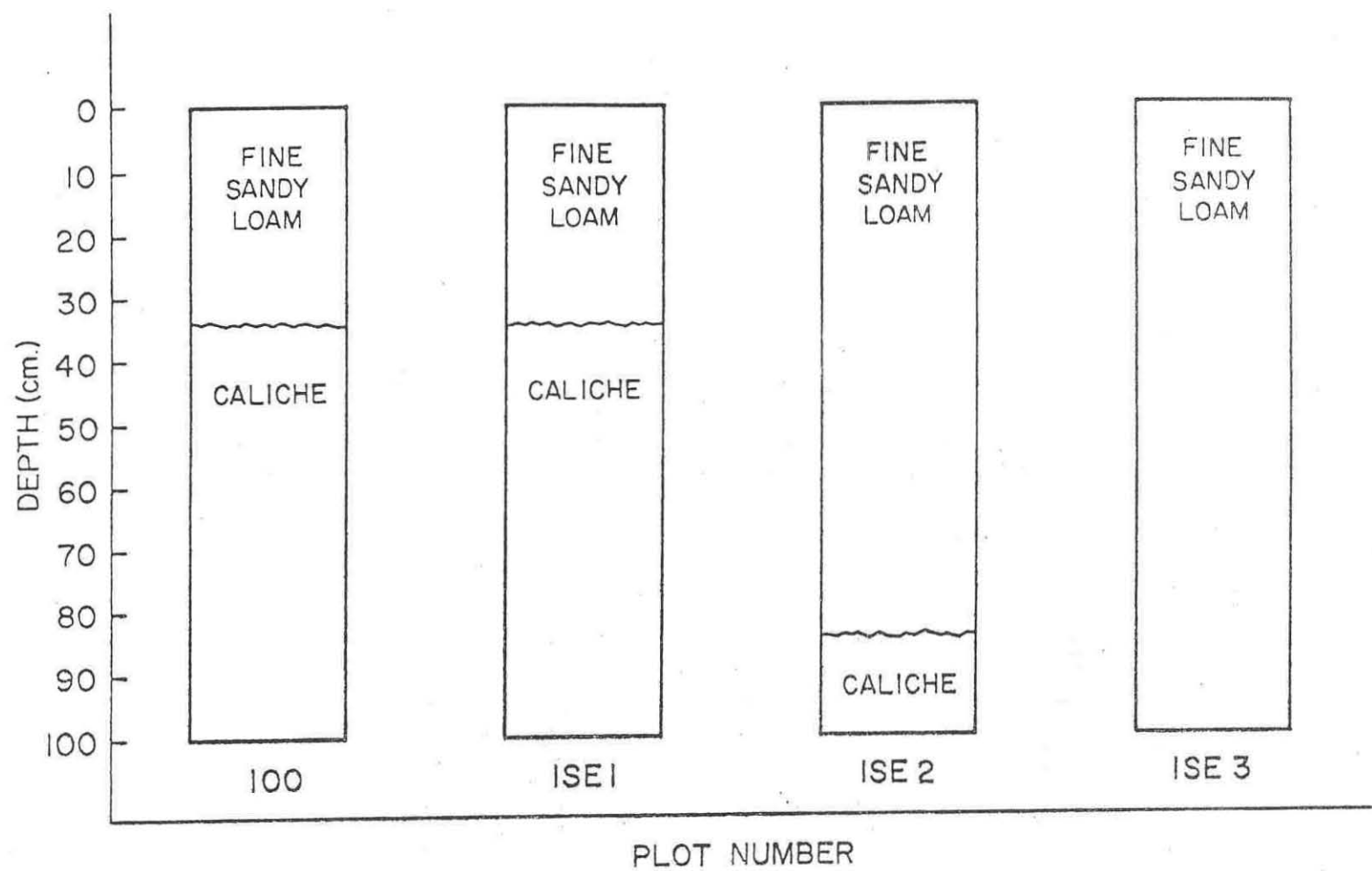
Soil type, structure, and total soluble salts content at each study plot in Organ Pipe Cactus

National Monument, 0-5 cm depth.

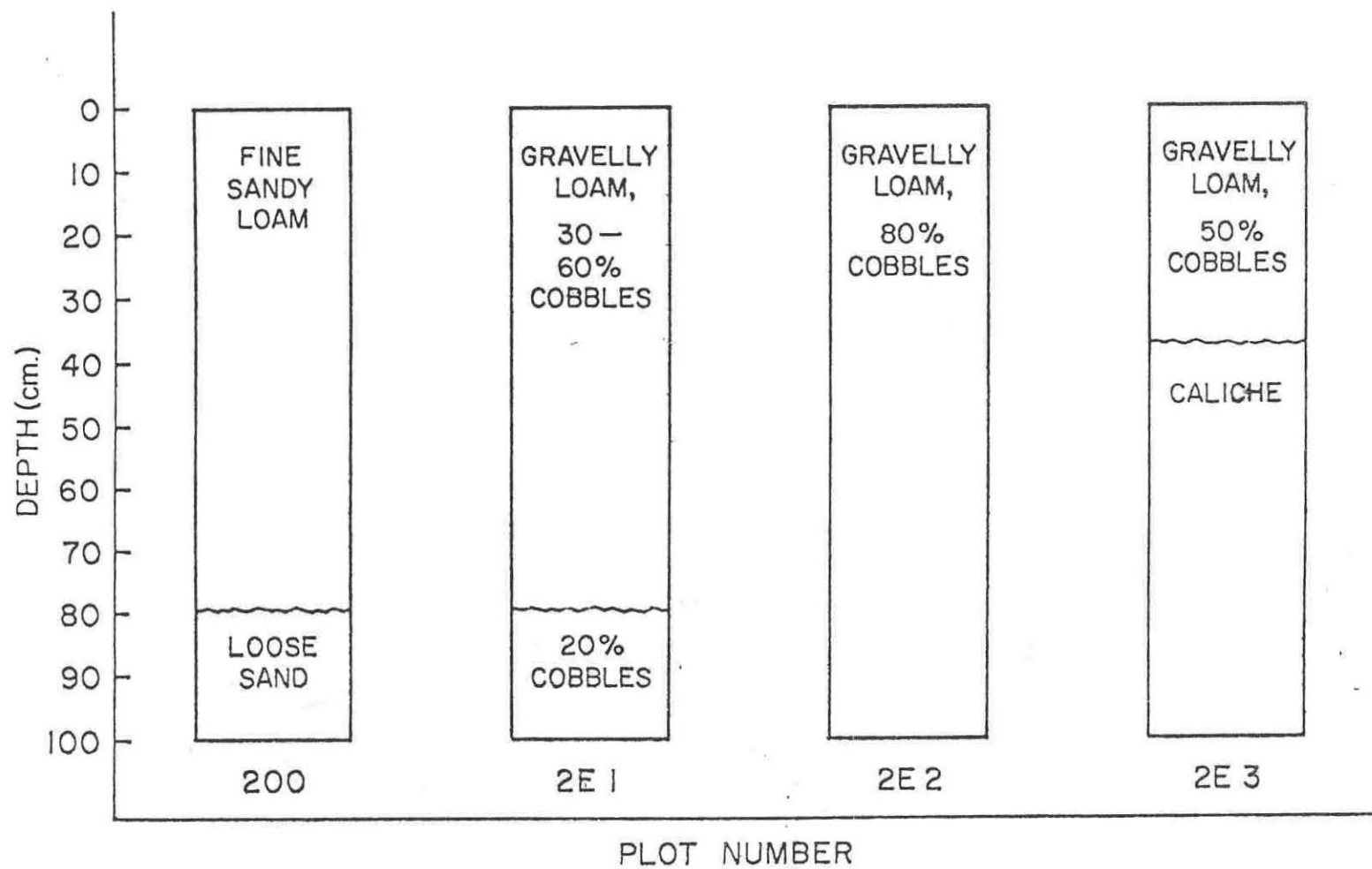
Plot	Soil Type ^{1/}	Sand	Silt %	Clay %	TSS ^{2/} ppm
100	fine sandy loam	58.5	31.0	10.5	217
1SE1	fine sandy loam	57.2	32.3	10.5	322
1SE2	fine sandy loam	65.0	26.5	8.5	368
1SE3	fine sandy loam	52.8	36.7	10.5	305
200	fine sandy loam	49.5	37.5	13.0	382
2E1	gravelly loam	65.0	22.2	12.8	329
2E2	gravelly loam	47.5	35.7	16.8	704
2E3	gravelly loam	59.2	30.3	10.5	1267
300	very gravelly loam	38.5	37.3	24.2	336
3S1	very gravelly loam	48.5	31.5	20.0	347
3S2	very gravelly loam	42.5	42.5	15.0	228
3S3	very gravelly loam	46.0	36.2	17.8	200
3S4	very gravelly loam	55.0	28.2	16.8	319
400	gravelly, loam	63.5	23.7	12.8	259
4W1	gravelly loam	71.2	18.0	10.8	231
4W2	gravelly loam	65.5	21.7	12.8	298
DLX	fine sandy loam	26.0	56.0	18.0	308
AWX	very fine sandy loam 41.0		44.0	15.0	280

^{1/} From U.S.D.A. Soil Conservation Service, 1972

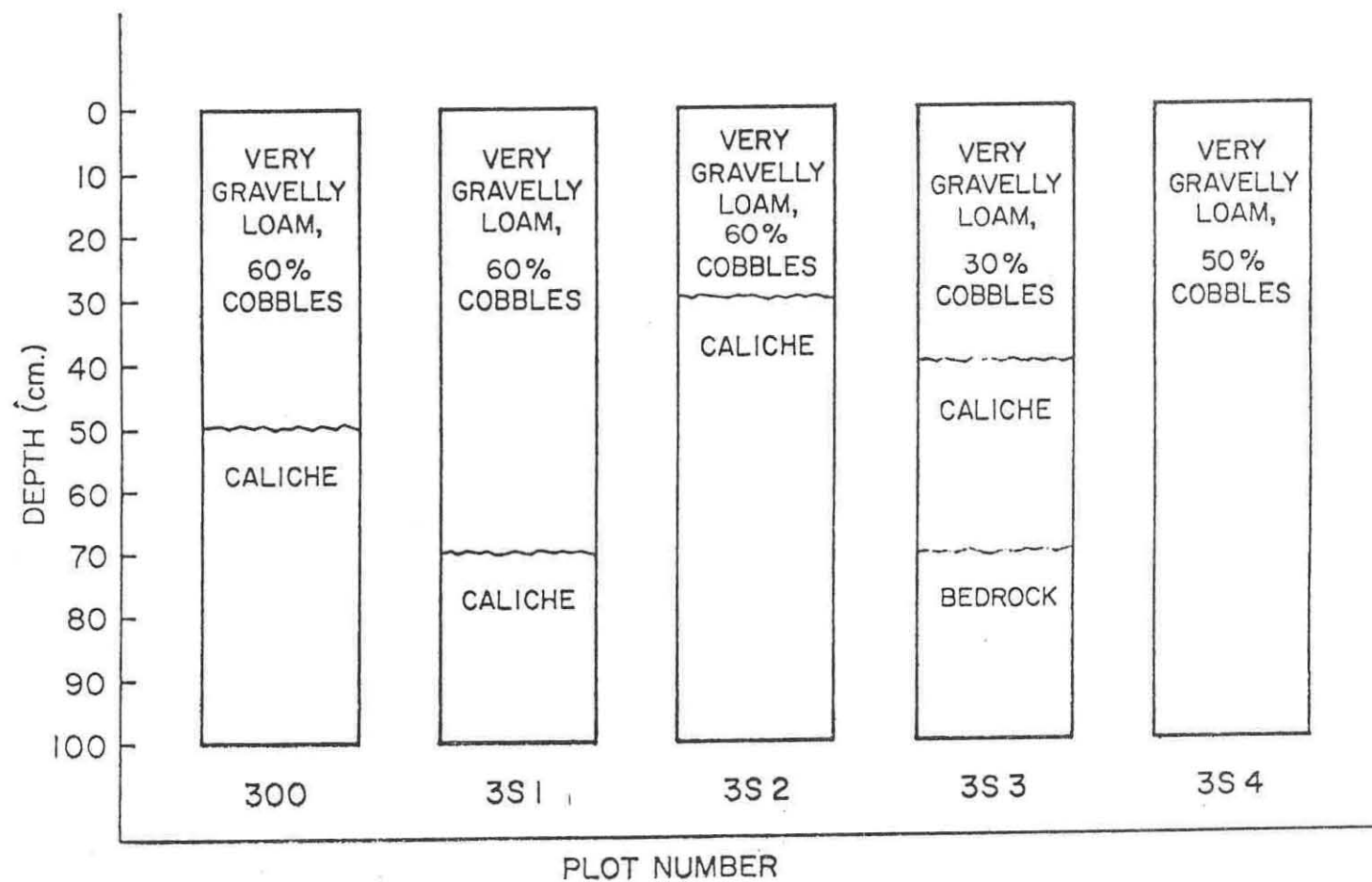
^{2/} Mean of two determinations. Values greater than 2800 ppm considered saline (U.S. Salinity Laboratory, 1954).



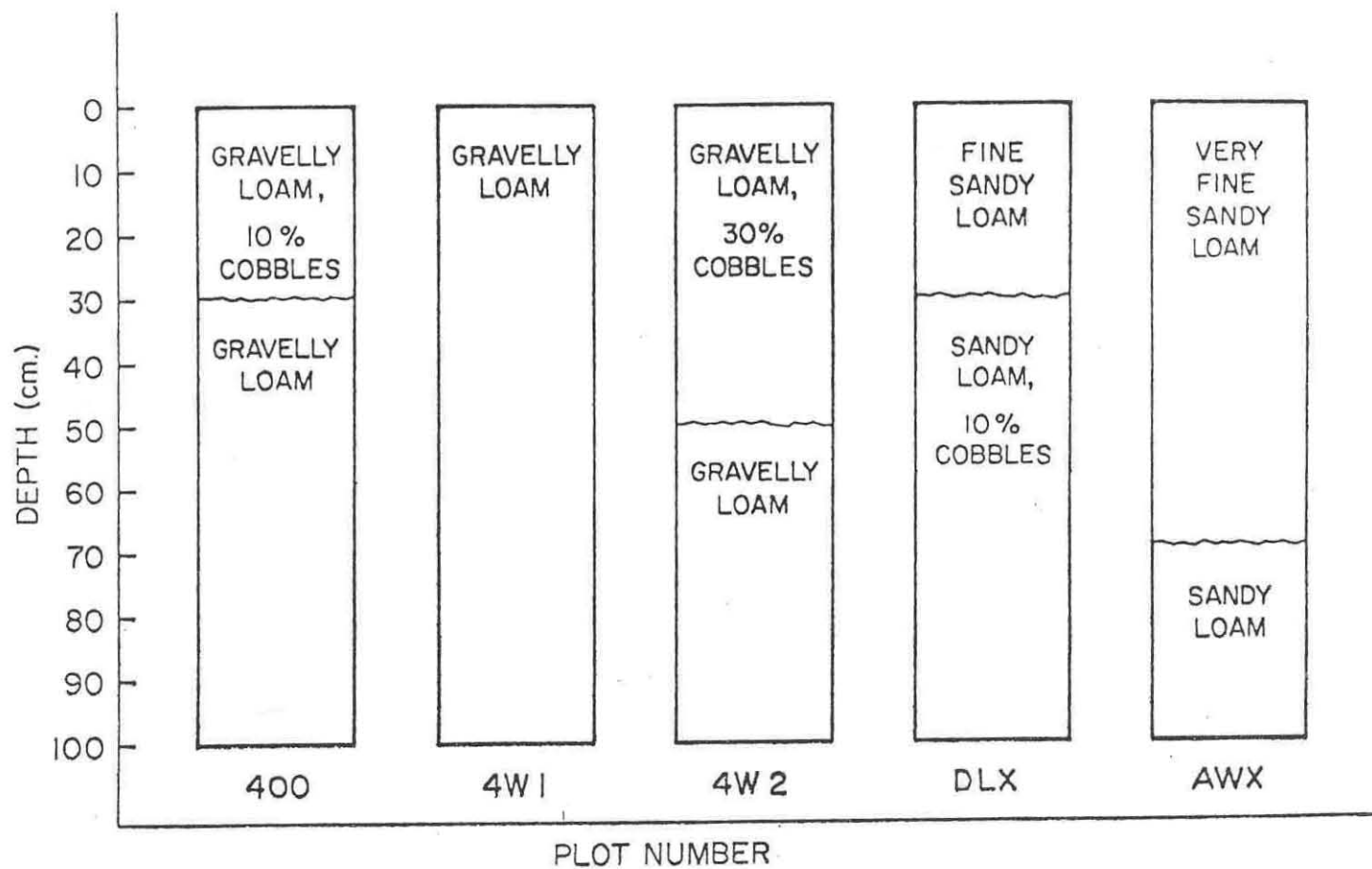
APPENDIX VI (cont.): Soil profiles.



APPENDIX VI (cont.): Soil profiles.



APPENDIX VI (cont.): Soil profiles.



APPENDIX VI (cont.): Soil profiles.

APPENDIX VII

Occurrence of rodent species in 20 study plots in Organ Pipe Cactus National Monument

Species	Plot No.																			
	100	1SE1	1SE2	1SE3	200	2E1	2E2	2E3	300	3S1	3S2	3S3	3S4	400	4W1	4W2	DLX	DLC	AWX	AWC
Heteromyidae																				
<u>Dipodomys deserti</u>																			X	X
<u>Dipodomys merriami</u>	X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X	X
<u>Perognathus amplus</u>	X	X				X	X	X									X			
<u>Perognathus baileyi</u>							X		X	X	X	X	X				X			
<u>Perognathus penicillatus</u>		X	X		X	X	X	X					X	X	X	X	X	X		X
Cricetidae																				
<u>Neotoma albigula</u>							X		X				X	X		X	X			
<u>Onychomys torridus</u>				X													X	X		
<u>Peromyscus eremicus</u>									X	X	X	X	X				X			

APPENDIX VIII

MANAGEMENT RECOMMENDATIONS

Under the authority of the Antiquities Act of 1906, Organ Pipe Cactus National Monument was set aside because of its scientific interest. Specifically, that interest lies in the unique and characteristic natural biotic resources of the area. These include associations and interdependent relationships of species of plants and animals found nowhere else in the United States.

The primary purpose of the monument lies in the preservation of these natural associations and interrelationships. The primary function of the National Park Service in the management of these resources is to maintain the natural integrity of these biotic communities by measures to eliminate or minimize human-caused impact on the natural communities and processes, and where necessary, to actively contribute to the restoration of degraded natural environments.

Livestock Grazing

Grazing by domestic livestock is a consumptive use of natural resources that is entirely incompatible with the legislated purposes of Organ Pipe Cactus National Monument. The immediate elimination of livestock grazing is the single most important resources management need of this time. That need becomes increasingly urgent as irreversible deterioration of resources accelerates under continued grazing pressure. The elimination of livestock grazing will, to a large extent, halt further grazing-caused deterioration, and will allow natural ecological processes to operate toward the regeneration of degraded natural environments and biotic communities.

Previous evaluations of grazing impact oriented primarily toward the production and availability of forage for livestock have seriously underestimated the overall impact of livestock grazing upon non-forage plant species, and native animal populations. The destructive impacts of livestock grazing within the monument are widespread, and have resulted not only in major damage to natural plant communities, but such use has also significantly affected native wildlife populations

Follow-up Studies

Follow-up comparative studies using techniques and study sites employed in this investigation will be required to realize the full benefit of the results reported here. The function of these follow-up studies, and time-tables for their accomplishment are contingent upon the success or failure of pending action to terminate livestock grazing in the monument.

At the time this investigation was initiated, it was expected that termination of livestock grazing within the monument would occur during the period of the study. However, cattle continue to graze in the monument with no prospect for their removal in the near future. With continued grazing these data, originally intended to serve as a basis for determining rates of natural recovery, instead become a basis for measuring further grazing caused deterioration.

If cattle are removed by the end of 1977, the data provided here should still be usable as a baseline for determination of natural regeneration rates. However, the validity of these results as baseline data for that purpose should be confirmed at the time cattle are removed. This, at minimum, would entail repetition and comparative evaluation of aerial and ground photography. The status of rodent and plant populations within exclosures should again be documented at that time. A complete follow-up study should be undertaken 5 years after cattle are removed, and repeated at 5-year intervals thereafter to provide a complete and continuous record of natural recovery.

If removal of cattle occurs after 1977, a repetition of the present study should be completed at the time cattle are removed, and repeated at 5-year intervals thereafter. Similarly, any major change in grazing practices should be accompanied by a repetition of the study to provide a basis for monitoring the effects of such change.

If cattle grazing is allowed to continue without major change in grazing practices, the study should be repeated within a maximum of 5 years (1980) from the date of the present data collection. Monitoring by yearly repetition of aerial and ground photography is recommended. Furthermore, if grazing is allowed to continue for an extended period, additional livestock exclosures and control plots should be installed in unique and representative communities, and monitored to provide further information on the impact of such grazing. In addition, cattle should be excluded by fencing from unique and highly sensitive sites such as Aguajita Spring.

Other Related Research Needs

It must be emphasized that although this investigation provides a useful index to the status of natural communities, there remain unanswered a number of important grazing related questions. The original (pre-grazing) condition of natural communities and the history of human use and subsequent changes in those conditions are unknown. The composition and distribution of native plant communities has not been documented. The nature and extent of competition between cattle and native wildlife has not been determined. The relationship of developed livestock water sources to native wildlife populations is likewise undefined.

All of the above are important questions requiring research for their solution. The answers, however, are critical to the development and implementation of resources management programs that will effectively restore and maintain the basic integrity of the unique natural biotic communities and ecological relationships of the Organ Pipe Cactus National Monument.